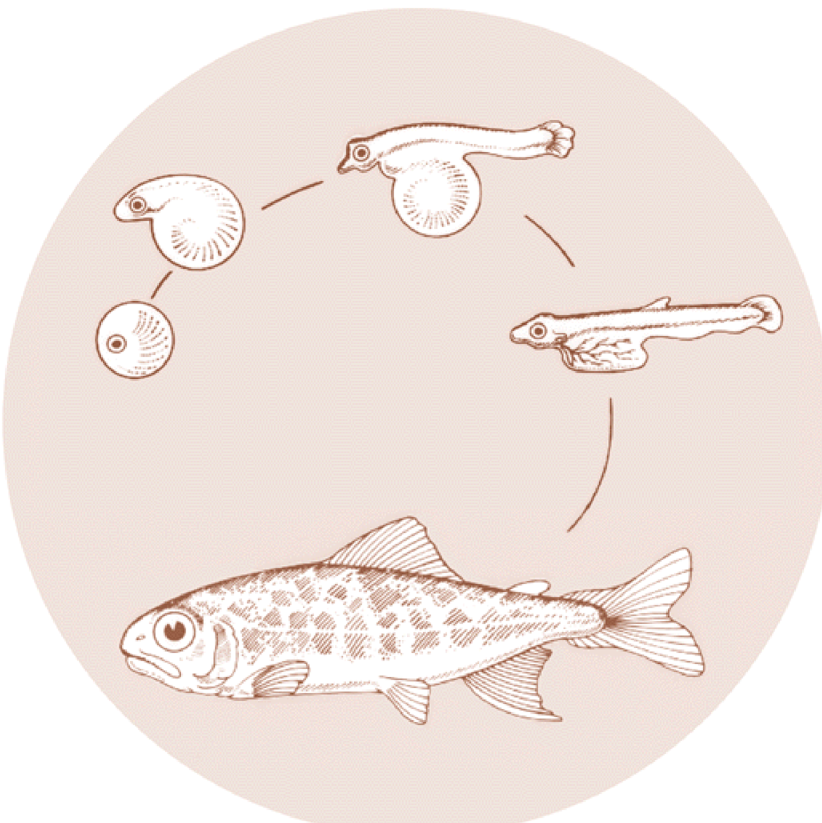
FISH RESEARCH PROJECT - OREGON
UMATILLA HATCHERY MONITORING AND EVALUATION

Project Period:
November 1, 1993 - October 30, 1994



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EXECUTIVE SUMMARY

This report covers the first three years of comprehensive monitoring and evaluation of the Umatilla Hatchery. Because the hatchery and the evaluation study and the fish health monitoring investigations are in the early stages of implementation, much of the information contained in this report is preliminary. The majority of the data that is crucial for evaluating the success of the hatchery program, the data on post-release performance and survival, is yet unavailable. In addition, several years of data are necessary to make conclusions about rearing performance at Umatilla Hatchery. The conclusions drawn in this report should be viewed as preliminary and should be used in conjunction with additional information as it becomes available.

Objectives for FY 1994

Hatchery Monitoring and Evaluation

1. Document egg-take, and egg-to-fry and egg-to-smolt survival rates for fall chinook salmon, spring chinook salmon, and summer steelhead reared at Umatilla Hatchery and released into the Umatilla River.

2. Document rearing densities and loading factors for fall chinook salmon, spring chinook salmon, and summer steelhead reared at Umatilla Hatchery and released into the Umatilla River.

3. Document number, size, time, and release location for fall chinook salmon. spring chinook salmon, and summer steelhead reared at Umatilla and Bonneville hatcheries and released into the Umatilla River.

4. Monitor water quality parameters in an index series of Michigan or Oregon raceways in which fall chinook salmon, spring chinook salmon, or summer steelhead were reared.

5. Collect and compare monthly measurements of length, weight, and condition factors for fall chinook salmon, spring chinook salmon, and summer steelhead reared in the Michigan or Oregon systems at Umatilla Hatchery.

6. Calculate and compare growth rates for fall chinook salmon, spring chinook salmon, and summer steelhead reared in Michigan or Oregon systems at Umatilla Hatchery.

7. Determine and compare fin condition, degree of descaling. degree of smolting. length. weight, and condition factor at release for fall chinook salmon, spring chinook salmon, and summer steelhead reared in the Michigan or Oregon systems at Umatilla Hatchery, and for spring chinook salmon reared at Bonneville Hatchery.

8. Compare the physiological stress response of fall and spring chinook salmon reared in Michigan or Oregon systems at Umatilla Hatchery.

9. Compare the $Na^+K^+ATPase$ activity of gill tissue from subyearling and yearling spring chinook salmon reared at Umatilla Hatchery.

10. Cold brand and release representative groups of fish reared at Umatilla Hatchery, including fall chinook salmon from all Michigan and Oregon raceways, subyearling spring chinook salmon reared in Michigan raceways, yearling spring chinook salmon reared in Oregon raceways, summer steelhead reared in Michigan raceways, and spring chinook salmon yearlings reared in standard raceways at Bonneville Hatchery to evaluate smolt migration performance.

11. Acquire recovery information for branded fall chinook salmon, spring chinook salmon, and summer steelhead reared in raceways at Umatilla or Bonneville Hatcheries and compare relative survival and characteristics of the migration to John Day Dam.

12. Fin mark, coded-wire-tag or blank-wire-tag, determine tag retention and fin clip quality, and release replicate groups of fall chinook salmon, spring chinook salmon. and summer steelhead to evaluate smolt-to-adult survival.

13. Collect coded-wire and blank-wire-tag information from previously released groups of fall chinook salmon, spring chinook salmon, and summer steelhead from Umatilla and Bonneville Hatcheries.

14. Develop and implement statistical creel methods and report results of 1993-1994 creel surveys to estimate sport harvest of summer steelhead. spring chinook salmon, and fall chinook salmon.

15. Participate in the development of a water quality sampling and monitoring program in the Umatilla Basin.

16. Participate in planning the production and management activities of anadromous fish in the Umatilla River Basin.

Fish Health Monitoring and Evaluation

1. Conduct monthly fish health examinations on fresh dead or moribund, and healthy juvenile fish from index raceways of each species and stock of fish reared at Umatilla Hatchery.

2. Conduct preliberation fish health examinations on 30 Juvenile fish per index raceway of each species and stock of fish reared at Umatilla Hatchery.

3. Conduct preliberation fish health examinations on 30 Juvenile fish per evaluation raceway of 1994 brood year Bonneville yearling fall chinook salmon at Bonneville Hatchery.

4. Collect gills at preliberation from 10 Juvenile fish from a cross-section of upper, middle and lower Michigan raceways, and upper and lower Oregon raceways, for histological examination.

5. Using data obtained from monthly and preliberation fish health examinations, assess what effects differing rearing strategies and environments have on fish health.

6. Examine fish when unusual loss or behavior occurs by appropriate diagnostic methods. Implement therapeutic or prophylactic measures to control, moderate or prevent disease outbreaks.

7. Continue implementation of Federal Drug Administration Investigational New Animal Drug erythromycin experimental feeding protocols for the juvenile spring chinook salmon at Umatilla Hatchery.

8. Implement Federal Drug Administration Investigational New Animal Drug oxytetracycline experimental feeding protocols for the juvenile fall chinook salmon at Umatilla Hatchery.

Accomplishments and Findings for FY 1994

Hatchery Monitoring and Evaluation

We achieved all of our objectives in FY 1994. However, spring chinook salmon produced at Bonneville Hatchery intended for fall release were held over and released as yearlings in FY 1994.

More than 5 million salmon and steelhead were released into the Umatilla River as planned from November 1993 to May 1994. The production of spring chinook salmon released in the fall was 31K below the FY 1994 goal. The size at release of spring chinook salmon in the fall and spring chinook salmon subyearlings were 33% smaller than planned.

Fall chinook salmon and spring chinook salmon released in the fall and reared in Oregon raceways were 10% larger than fish reared in Michigan raceways. In addition, fish reared in Oregon raceways were more efficient at converting feed and suffered lower levels of descaling than fish reared in Michigan raceways. Fish reared in different passes of the Michigan or Oregon raceways suffered similar levels of descaling.

There were few differences in plasma cortisol and glucose levels of fish reared in Michigan or Oregon raceways. Fall chinook salmon subyearlings and spring chinook salmon released in the fall from each system responded to stress in a similar manner.

Peak ATPase activity did not coincide with release date for spring chinook salmon released in the fall or spring chinook salmon subyearlings. The ATPase activity levels of yearlings and subyearlings was lower in actively migrating fish collected at Three Mile Falls Dam than levels measured from fish on the day of release.

To study migration we successfully branded fish in raceways containing fall chinook salmon, spring chinook salmon, and summer steelhead at Umatilla and Bonneville Hatcheries. The median travel time of fall chinook salmon subyearlings to the John Day dam was approximately 38 days. Spring chinook salmon subyearlings released in the upper Umatilla River in May required 20 days to reach the John Day dam compared to 40 days for yearlings released in March. We found no difference in the migration rate or survival index of spring chinook salmon yearlings reared at Umatilla or Bonneville Hatcheries. Despite faster migration, subyearlings had a lower survival index compared to yearlings. Some spring chinook salmon migrated to Three Mile Falls Dam in less than 5 days, suggesting that much of the travel time to the John Day Dam was spent in the lower Umatilla River or in the Columbia River. Most summer steelhead released in April required 40 days to reach John Day dam but fish released in May required only 10-20 days.

Fall chinook salmon, spring chinook salmon, and summer steelhead were successfully fin clipped and coded-wire-tagged. More than 2.3 million fall chinook salmon were blank-wire-tagged in 1994 and tag retention averaged 97%. The quality of the ventral fin clip to identify fall chinook salmon subyearlings was very good and only 3.0% were poorly clipped or unclipped. Ventral fin clip quality of spring chinook salmon yearlings was poor for fish produced at Bonneville Hatchery. We found that more than 29% of the fish possessed poor clips or were unclipped.

Adult fall chinook salmon with blank-wire-tags returning to the Umatilla River were identified in 1993. However, the reliability of tag detection was uncertain and new methods are being developed.

Ten percent of the fall chinook salmon jacks and 5% of the coho salmon estimated to enter the Umatilla River were harvested between Three Mile Falls Dam and the mouth of the Umatilla River in 1993. Angling pressure during the 1993 fall chinook-coho salmon season and in the 1993-1994 steelhead season was 25% lower than in the previous year and catch rates ranged from 63-78 h/fish for both fisheries.

Fish Health Monitoring and Evaluation

Adult fall chinook fish health monitoring was conducted on fish spawned at Priest Rapids and Minthorn for Umatilla Hatchery production. Both stocks were negative for culturable viruses. *Renibacterium salmoninarum* levels measured by ELISA in the Priest Rapids fish were all in the negative/very low positive range. Most Umatilla adults were also in this range with the exception of a few in the low range.

One female adult steelhead had a clinical level of *R. salmoninarum* antigen and two were in the moderate range. Two juvenile mortalities and one grab-sampled steelhead were also in the moderate range.

Adult spring chinook fish health monitoring at Carson NFH indicated that the levels and prevalences of *R. salmoninarum* in the parental stocks for the 93 brood year juveniles were far below those in the 92 brood year parental stock.

Progeny of the 92 brood year parental stock of Carson spring chinook experienced the first episodes of bacterial kidney disease (BKD) at Umatilla Hatchery. Mortality rates were higher in Michigan raceways but not different among Michigan raceways. Potential BKD was more predominant in the fall release fish than in the spring release yearlings. Erythromycin appears to have controlled the outbreak in the yearlings.

Fall release progeny of the 93 brood year parental stock of Carson spring chinook experienced an outbreak of BKD. Losses were significantly higher in the lower Michigan raceways. Erythromycin was required to control this outbreak. No differences in *R. salmoninarum* antigen distributions were detected among raceways at liberation.

Erythromycin toxicity continues to be observed following dietary treatments.

Flexibacter psychrophilus, the agent of bacterial cold water disease, continues to be the second most common systemic pathogen detected. Most frequently in steelhead juveniles and second in juvenile fall chinook. No unusual losses were attributed to it.

Statistical evaluations of 30-fish sample groups for the ELISA showed that occasional differences between sample groups within a raceway and between raceways can occur.

Management Implications and Recommendations

Hatchery Monitoring and Evaluation

1. Preliminary data indicates that oxygen supplementation can be used to increase the production of fall chinook salmon, spring chinook salmon and summer steelhead. Rearing fish in Michigan raceways has allowed us to produce more fish with less water.

2 The quality of fall chinook salmon and spring chinook salmon smolts reared in Michigan and Oregon raceways is similar, but differs in some attributes. Continued

monitoring will allow us to determine if differences occur in adult return rates for Michigan and Oregon reared fish.

3. Monitoring showed that some spring chinook salmon released in the upper Umatilla River began outmigration immediately and quickly passed Three Mile Falls Dam. Based on median travel time to the John Day dam, the majority of the migration was spent in the lower Umatilla River or in the Columbia River. If total travel time is an important factor in smolt survival, actions to improve survival may be required.

4. Based on smolt condition and migration rate, we are capable of producing spring chinook salmon yearlings at Umatilla Hatchery that are similar to the quality of yearlings produced at Bonneville Hatchery. We also recommend that the fin clip quality of yearlings from Bonneville Hatchery be improved to insure adequate visual identification. Spring chinook salmon yearlings undergo an extensive period of chilling during the egg stage at Umatilla Hatchery and yearlings produced at Bonneville Hatchery serve as a control to Umatilla production.

5. Successful implantation of blank-wire-tags will increase the ability of biologists to identify and remove Umatilla basin fall chinook salmon that have strayed into the Snake River basin. This is an important factor in maintaining the fall chinook salmon program.

Fish Health Monitoring and Evaluation

Future rearing strategies for spring chinook at Umatilla Hatchery should incorporate segregation of progeny according to the *R. salmoninarum* ELISA ranges of female adults. This would require 100% sampling of females. Low density rearing and erythromycin therapy for juveniles from moderate-to-clinical level females could then be implemented as control strategies. The alternative is eliminating eggs from high and clinical level females.

REPORT A

Hatchery Monitoring and Evaluation

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UMATILLA HATCHERY MONITORING AND EVALUATION

INTRODUCTION

The Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program authorized construction of the Umatilla Hatchery in 1986. Measure 703 of the program amended the original authorization for the hatchery and specified evaluation of the Michigan type of rearing using oxygen supplementation to achieve production goals of 290,000 lb of steelhead *(Oncorhynchus mykiss)* and chinook salmon *(Oncorhynchus tshawytscha)*. The hatchery was completed in the fall of 1991. Partial justification for the hatchery was to provide the opportunity to develop considerable knowledge and understanding of new production and supplementation techniques. The use of the Michigan type of rearing at Umatilla Hatchery was selected because it could increase smolt production given the limited hatchery well water supply and would provide an opportunity to compare the Michigan type of rearing with the standard Oregon method. Results of testing the Michigan method of rearing will have systemwide application in the Columbia Basin.

The Umatilla Hatchery is the foundation for rehabilitating chinook salmon and enhancing summer steelhead in the Umatilla River (CTUIR and ODFW 1990) and is expected to contribute significantly to the Northwest Power Planning Council's goal of doubling salmonid production in the Columbia Basin. Hatchery production goals and a comprehensive plan for monitoring and evaluation are presented in the Umatilla Hatchery Master Plan (CTUIR and ODFW 1990). The Comprehensive Plan for Monitoring and Evaluation of Umatilla Hatchery (Carmichael 1990) was approved by the Northwest Power Planning Council as a critical part of the adaptive management process that guides the fisheries rehabilitation program in the Umatilla River. This process uses monitoring and evaluation to increase knowledge about uncertainties inherent in the fisheries rehabilitation program and will complement the developing systemwide monitoring and evaluation program.

The monitoring and evaluation goals are:

1. Provide information and recommendations for culture and release of hatchery fish. harvest regulations, and natural escapement that will lead to the accomplishment of long-term natural and hatchery production goals in the Umatilla River Basin in a manner consistent with provisions of the Council's Columbia River Basin Fish and Wildlife Program.

2. Assess the success of achieving the management objectives in the Umatilla River Basin that are presented in the Master Plan and the Comprehensive Rehabilitation Plan.

A substantial proportion of the production at Umatilla Hatchery will be produced in the "Michigan Type" oxygen supplementation system. This rearing system has not been thoroughly evaluated to determine the effects on smolt-to-adult survival. In addition, the rearing strategies proposed for spring chinook salmon are somewhat different than normal. Production of yearling smolts will require an unusually extensive period of incubation in chilled well water. The monitoring and evaluation program objectives for this report period were:

1. Document fish cultural and hatchery operational practices.

2. Monitor water quality parameters in a series of Michigan and Oregon raceways for each species reared.

3. Determine to what extent the efficiency of producing adult fall chinook salmon, spring chinook salmon. and summer steelhead can be increased through the Michigan rearing method.

4. Determine and compare smolt migration performance and smolt to adult survival of fall chinook salmon, subyearling and yearling spring chinook salmon, and summer steelhead.

5. Identify and compare the effects of tagging and marking on smolt-to-adult survival of subyearling fall chinook salmon smolts.

6. Coordinate in the development of a water quality sampling and monitoring program in the Umatilla River Basin.

7. Participate in planning and coordination activities associated with anadromous fish production, 'passage, monitoring, and evaluation in the Umatilla River Basin.

8. Monitor and evaluate the health of fish at Umatilla Hatchery.

Extensive background and justification for Umatilla Hatchery monitoring and evaluation is presented in Carmichael (1990). In this report, we present a review of our activities and findings for the Umatilla Hatchery Monitoring and Evaluation Project from I November 1993 to 31 October 1994. We have designed our program to include evaluation studies in the following categories: fish cultural practices. water quality monitoring, rearing performance and survival studies, spring chinook salmon yearling and subyearling production evaluation, spring chinook salmon fall release program, fall chinook salmon marking and tagging evaluation, creel surveys, and planning and coordination.

STUDY SITE

The Umatilla fish hatchery is located approximately seven miles from the town of Irrigon, Oregon (Figure 1). The hatchery is operated under a cooperative agreement among the Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation, the Bonneville Power Administration, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers. A schematic diagram illustrating the raceway configuration for the Umatilla Hatchery is displayed in Figure 2.

The Umatilla Hatchery was designed for production of salmonids in oxygen supplemented "Michigan" type raceways and in non-oxygen supplemented standard "Oregon" type raceways. Specific information about the hatchery is available in the Umatilla Hatchery Master Plan (CTUIR and ODFW 1990) and in the Environmental Assessment Report (Bonneville Power Administration 1987). The Michigan system consists of eight series of raceways with three raceways per series for a total of 24 raceways. Water flows from the upper raceway (A) to the middle raceway (B) and then to the lower raceway (C) within each series. Before the water enters each raceway, pure oxygen is supplemented through a pipe injection system. Physical characteristics of the raceways appear in Table 1. In each Michigan raceway there are nine baffles placed 10-11 ft apart to promote water movement across the bottom and aid in raceway cleaning. The raceways were cleaned by vacuuming at the outflow screen three times per week and brush cleaned once per week. Because of water availability problems, not all Michigan raceways were operated in 1993-94.

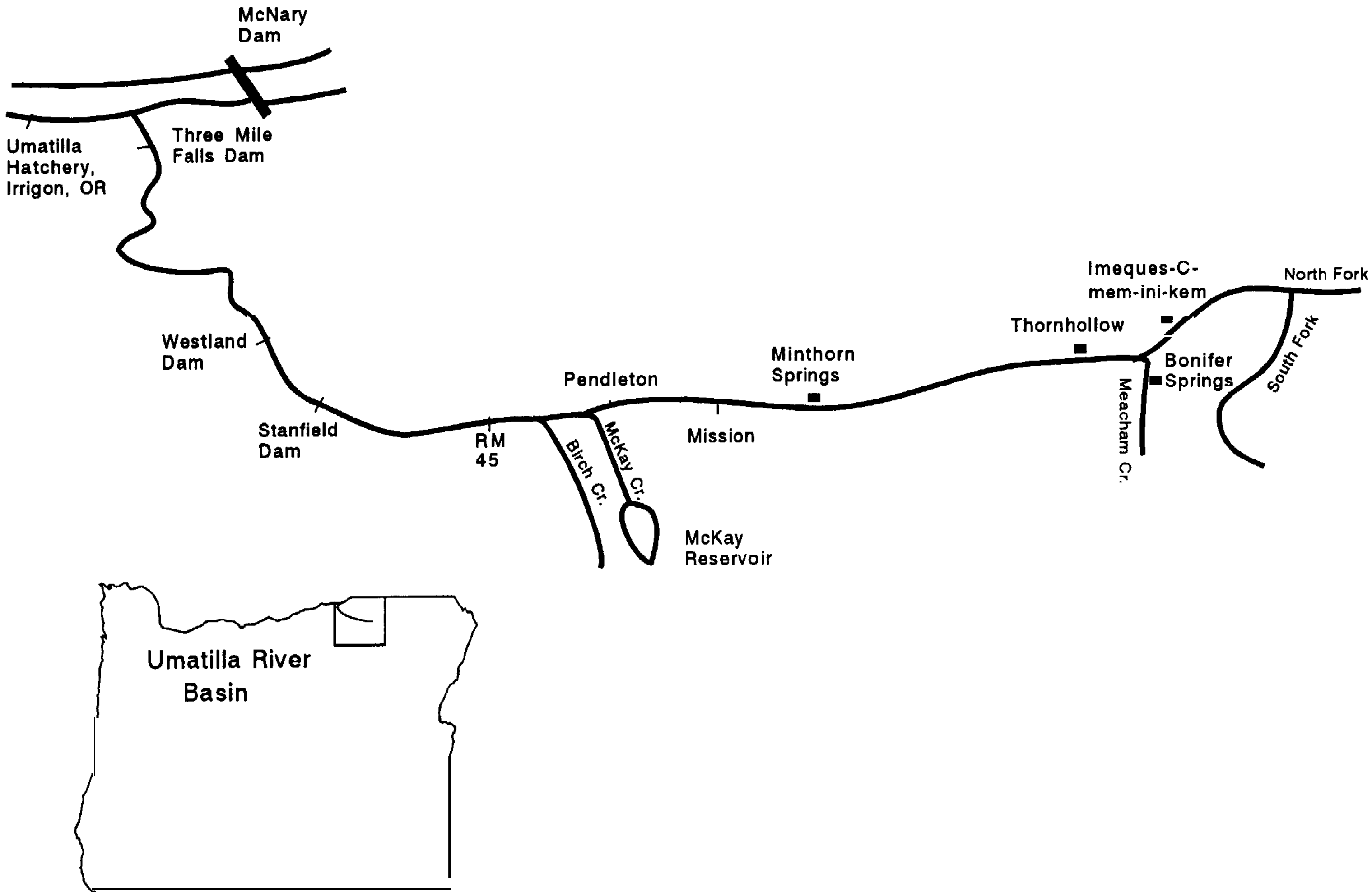


Figure 1. Location map. Umatilla Basin

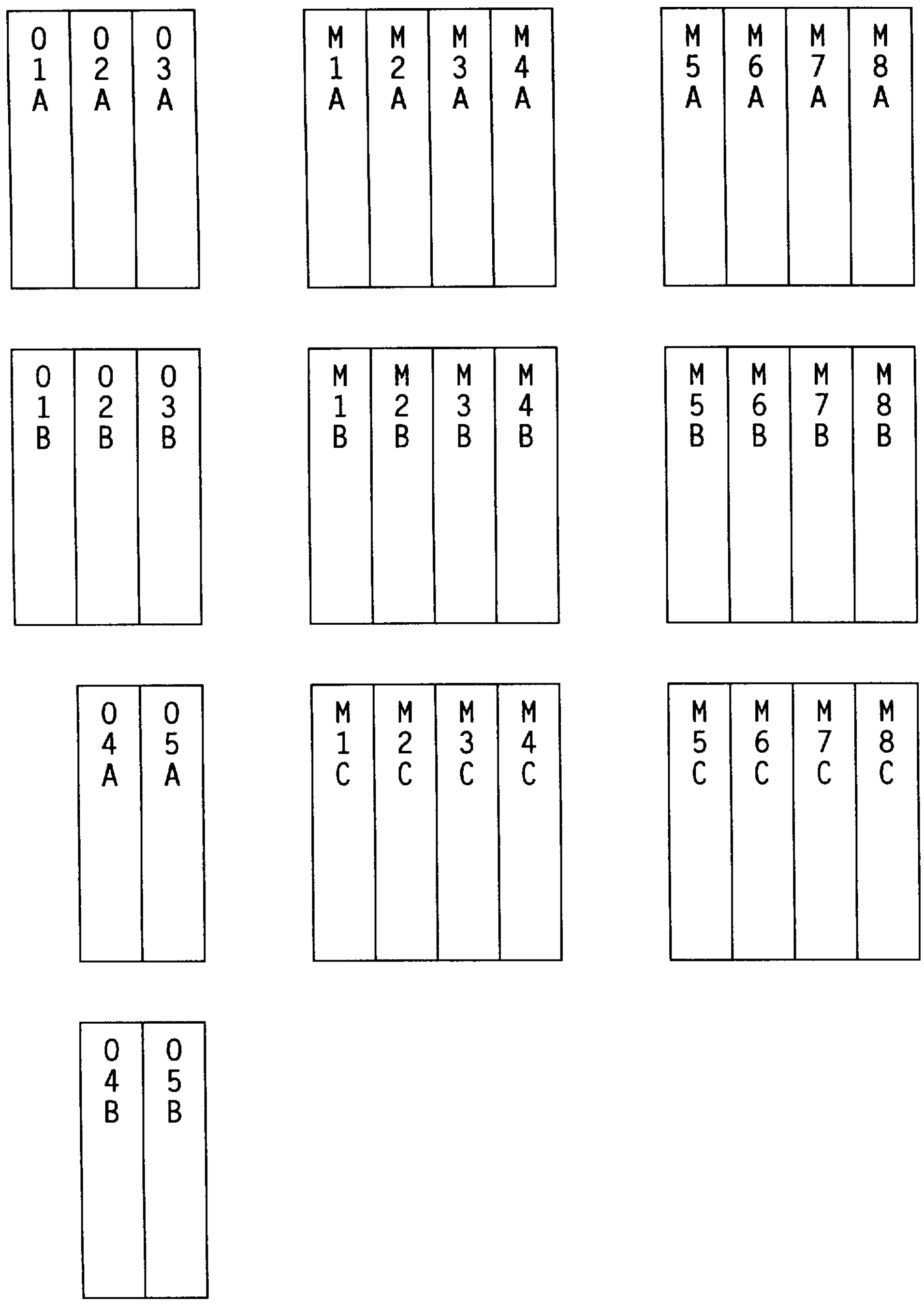


Figure 2. Raceway schematic for Umatilla Hatchery (O = Oregon raceway, M = Michigan raceway, number = raceway, A = first pass, B = second pass, C = third pass).

Table 1. Physical characteristics of the Oregon and Michigan raceways located at Bonneville Hatchery, Bonneville, Oregon and at Umatilla and Irrigon Hatcheries, Irrigon, Oregon.

System	Location	Length ft (m)	Width ft (m)	Water depth in (cm)	Volume ft^3 (m^3)	Flow gpm (lpm)
Michigan	Umatilla	91 (27.7)	9 (2.7)	30 (76)	2048 (58)	937 (3549)
Oregon	Umatilla	99 (30.2)	18.8 (5.7)	40 (102)	6200 (176)	1250 (4735)
Oregon	Irrigon	100 (30.5)	20 (6.1)	47 (119)	7833 (222)	1539 (5830)
Oregon	Bonneville	80 (24.4)	20 (6.1)	36 (91)	4800 (136)	600 (2273)

The Oregon system at Umatilla Hatchery consists of five series of raceways with two raceways per series for a total of 10 Oregon raceways (Table 1). Water flows from the upper raceway (A) to the lower raceway (B). No cleaning baffles are present in Oregon raceways and they were vacuumed once per week at the outflow screen and broom cleaned once per week. All 10 Oregon raceways were used in 1993-94.

For the summer steelhead, we compared Umatilla River strain to Wallowa stock reared in the Irrigon Hatchery. All raceways at the Irrigon site were Oregon style, but were slightly larger at 30.5 m long and 6.1 m wide. Water height was kept at 117 cm. Physical characteristics of each raceway are presented in Table 1.

The Umatilla River and tributaries are located in Umatilla, Morrow, and Union counties, Oregon (Figure 1). Tests or evaluations of fall and spring chinook salmon were conducted at the Umatilla Hatchery, Imeques C-Mem-Ini-Kern acclimation site (river mile 80), and the Thornhollow release site (Umatilla River mile 74). Summer steelhead evaluations were conducted at Umatilla Hatchery and the Bonifer and Minthorn springs acclimation sites.

METHODS

Fish Cultural Practices

We monitored fish cultural and hatchery operational practices at Umatilla Hatchery. Hatchery records were used to determine the number of eggs taken, egg mortality, fry mortality, and smolts released. Egg-to-smolt survival rates were calculated for fall chinook salmon, spring chinook salmon, and summer steelhead. The number of fish released, the size of fish released for major production groups, and the location of release were determined from hatchery records.

Water Quality Monitoring

We monitored water quality in an index series of Michigan and Oregon raceways in which fall chinook salmon and spring chinook salmon were reared and in a series of Michigan or Oregon raceways in which spring chinook salmon and summer steelhead were reared. Measurements were taken between 1100-1800 h on each sampling day and samples were collected weekly from April 1993 to mid-May 1994. Parameters measured at the head and tail of each raceway included: water temperature (°C), total gas pressure (mm Hg), partial pressure of oxygen (mm Hg), partial pressure of nitrogen (mm Hg), and pH. Parts per million of 02 were calculated from the partial pressure of O_2, pH, and temperature data. We used a Model TBO-F, Common Sensing meter to monitor gas pressure and a portable meter to determine pH. Both meters were calibrated immediately prior to each sampling period.

We determined total alkalinity and unionized ammonia from water samples collected biweekly at the tail of each raceway. Samples were collected between 0700 and 0900 h to minimize the influence of daily feeding activities and were sent immediately for analysis. We used the titration method (Standard Methods 1981) to determine the alkalinity (mg/l $CaCO_3$). Total ammonia concentrations were determined by an independent testing laboratory using the phenate method. The proportion of unionized ammonia was calculated from total ammonia, temperature, and pH.

Rearing Performance and Survival Studies

Fall Chinook Salmon

Rearing Performance: To evaluate rearing performance. mean length and weight were determined during rearing in 1993-1994. During monthly sampling we measured 100 fork lengths and 50 weights from a sample of fish out of each raceway. Length and weight data were used to calculate the condition factor (weight/length^3*100,000; Nielsen et al. 1983). Growth rates were determined by plotting mean monthly weight over time.

We calculated the mean food conversion ratio for fall chinook salmon in the Oregon and Michigan systems from food conversion ratios for each raceway. Ratios were determined after fish were split into their final raceway. The total weight gained by a group of fish in each raceway was calculated by subtracting the total weight at the start of the time period from the final weight at release. To estimate the food conversion ratio, we divided the total pounds of feed fed by the pounds of weight gained.

Smolt Condition: We examined smolts at pre-release to determine their general condition. Measurements included fork length, weight. smolt stage, and the amount of descaling. The pre-release sample was taken 7-10 days prior to liberation from the hatchery. At pre-release we measured fork lengths of 300 fish and weights of 100 fish from each raceway.

We documented the smolt stage from a sample of 200 fish in each raceway. To evaluate smoltification, we examined both sides of the fish and classified them as smolts if they were silvery and no parr marks were present. Fish with discernible, yet not a complete set of parr marks, were classified as intermediate smolts whereas fish with full parr marks were noted as parr.

To determine the extent of descaling, we examined 200 fish in each raceway and recorded the scale condition on each side of the body. We recorded scales as undamaged if the cumulative scale loss was less than 3% either side of the body. If cumulative scale loss exceeded 3% on one side of the body, but was less than 16%. we listed the side as partially descaled. Descaled sides were those that had a cumulative scale loss equal to or exceeding 20%.

We evaluated and compared the physiological stress response of fall chinook salmon reared in Michigan and Oregon systems to both a primary and secondary stressor. The physiological stress response was evaluated for the response to a primary stressor at the hatchery prior to release and for the response to a secondary stressor at the release site after transport from the hatchery. Plasma levels of cortisol and glucose were assayed for approximately 36 salmon from each raceway. Control fish were removed from the raceway or stocking truck and immediately euthanized with tri-methylcaine sulfate (MS-222). The eighteen treatment fish were subjected to a standardized stress by removing them from a raceway (primary stressor) at the hatchery or from the stocking truck (secondary stressor) at the release site and holding them out of water in a 0.1 sq m net pen for 30 seconds. The net pen containing fish was returned to the raceway or placed in the Umatilla River for one hour. After one hour the fish were euthanized with tri-methylcaine sulfate (MS-222). After euthanization we severed the caudal peduncle of each fish and collected blood samples in heparinized capillary tubes. The tubes were sealed, placed on ice, and transported to the laboratory. The tubes were spun with a microcentrifuge for two minutes to separate the plasma from the red blood cells. Because the fish were small, we usually pooled plasma samples from two fish to obtain a sufficient volume for analysis. The plasma was transferred into storage tubes, transported on dry ice, and stored in a supercool freezer (-80°C). These samples were analyzed by an independent laboratory for plasma concentrations of cortisol and glucose.

Smolt Migration Performance: We compared the smolt migration success, migration rate, and the duration of migration for fall chinook salmon reared in the Oregon and Michigan systems. To identify fish, we freeze-branded approximately 10,000 fall chinook salmon from each of the Oregon and Michigan raceways. The brands were approved by and coordinated with the National Marine Fisheries Service and the Fish Passage Center. Each raceway was assigned a unique brand. The branding rods were supercooled with liquid nitrogen and were applied to a fish for one second to leave a brand. To determine brand quality we subsampled approximately 100 fish from each raceway during pre-release sampling and evaluated each brand for readability based on the following criteria. Readable brands were those that were clearly readable and could not be mistaken for other brands. Light or faint brands were considered good. Obscure brands were light and possibly distorted or placed a little high or low, but were still legible. Non-readable brands were those which could not be recognized. This information, along with total numbers branded, was sent to the personnel at the Fish Passage Center in Portland, Oregon, who monitored downstream fish passage and recorded the numbers of branded fish observed at mainstem Columbia River dams. Brand recovery data was received from the Fish Passage Center. We compared the brand recovery rates and travel time to John Day Dam for fish reared in Michigan and Oregon raceways. Recovery rates were calculated by dividing the total estimated passage daily count by the total number of readable brands released. We also plotted the daily passage counts and the average cumulative index against days after release for all Michigan and Oregon release groups.

Smolt-to-Adult Survival: In the future we will compare the percentage of fall chinook salmon surviving from the smolt to the adult stage between Michigan and Oregon raceways. To identify fish from each raceway in 1994 we marked approximately 30,000 fall chinook salmon in each of 10 raceways with an adipose fin clip (AD+CWT) and coded-wire-tags. To assure accuracy of tagging, a subsample of 300-400 fish from each raceway was checked for tag retention a minimum of 14 days after tagging.

Straying: Fall chinook salmon released in the Umatilla River have strayed into the upper Columbia and Snake rivers in the past. All recovery information for marked Umatilla fall chinook salmon recovered at Ice Harbor Dam, Lower Granite Dam, Lyons Ferry Hatchery, Snake River spawning surveys, and at any other location in the Columbia basin will be summarized to evaluate straying. To identify fall chinook salmon released from Umatilla and Bonneville Hatcheries into the Umatilla River, most fish have been ventral fin-clipped since 1992. In addition, in 1994 all fall chinook salmon that were not marked with a coded-wire-tag were marked in the snout with a blank-wire-tag. To assure accuracy of tagging, a subsample of 300-400 fish from each raceway was checked for tag retention a minimum of 14 days after tagging.

We also evaluated the quality of the ventral fin clips on fall chinook salmon. Fin clips were categorized as: good if no fin or a small stub remained: fair if a fin stub of approximately 25% remained; poor when approximately 50% of the fin remained; and unclipped when more than 75% of the fin remained.

Spring Chinook Salmon Released in the Fall

Rearing Performance: The rearing performance evaluation for spring chinook salmon released in the fall was the same as for fall chinook salmon.

Smolt Condition: We monitored smolt condition of 1992 brood of spring chinook salmon that were released in the fall in the same manner as for fall chinook salmon except for the stress response test. Because spring chinook salmon were larger, we did not pool blood samples. Twenty-four fish were sampled from each raceway for these tests. In addition, gill ATPase levels were measured as a physiological index of smoltification. Gill samples were obtained at approximately 45, 30, and 15 days prior to release, and at the time of release. Three or four gill filaments were removed by cutting them from the left gill arches. Occasionally, we removed filaments from right arches. Once cut, the gill filaments were placed in a fixative (SEI buffer), transported on dry ice, and stored in a supercool freezer (-80°C). These samples were analyzed by an independent laboratory for Na^+K^+ATPase (µmoles P/h/mg of protein).

Smolt Migration Performance: Spring chinook salmon released in the fall were not freeze branded. Therefore. we did not evaluate the migration performance for these groups.

Smolt-to-Adult Survival: In the future, we will monitor the percentage of spring chinook salmon surviving from the smolt to the adult stage and compare survival between fish reared in Michigan and Oregon systems. To identify fish we Ad+CWT marked approximately 35,000 fish from each raceway. To assure accuracy of tagging, a subsample of 300-400 fish from each raceway was checked for tag retention a minimum of 14 days after tagging.

Spring Release Subyearlings

A Michigan versus Oregon rearing system evaluation was initiated with the 1991 brood subyearling chinook salmon released in the spring of 1992. The methods associated with this evaluation can be found in Keefe et al. (1993). Because of water limitations 1992 was the only year for this evaluation. Adult return data from 1992 releases are included in this and will be included in future reports.

Summer Steelhead

Rearing Performance: Summer steelhead rearing performance was monitored in the same manner as for fall chinook salmon excepting the system evaluation. In addition, we compared food conversion ratios between Michigan reared steelhead from Umatilla Hatchery and Wallowa stock steelhead reared in standard raceways at Irrigon Hatchery. The food conversion ratio for Wallowa stock steelhead was generated from data on 30 raceways; therefore, a mean value with associated statistics could not be computed. Additionally, because different feeds are used at Umatilla and Irrigon Hatcheries, we used dry protein to calculate food conversion ratios.

Smolt Condition: Smolt condition for summer steelhead was evaluated in the same manner as for fall chinook salmon with the following modifications. We compared pre-release data between Michigan reared, Umatilla steelhead and standard reared Wallowa steelhead raised in first pass ponds. In addition, we evaluated fin erosion on summer steelhead by examining all fins on approximately 200 fish per raceway as described in the 1992 annual report (Keefe et al. 1993). No tests between passes were conducted because summer steelhead were graded prior to ponding in Michigan raceways. Pre-release data was obtained at the Minthorn and Bonifer Springs acclimation sites for Umatilla steelhead and at the Wallowa and Big Canyon acclimation sites for Wallowa steelhead.

Smolt Migration Performance: In 1994 approximately 10,000 fish in each Michigan raceway were branded. Branding methods were the same as described for fall chinook salmon. Smolt migration success, migration rate, and the duration of migration were monitored for all Michigan passes.

Smolt-to-Adult Survival: To identify fish from each raceway in 1994 we coded-wire-tagged plus LV marked two replicates of approximately 10,000 fish from each raceway. A subsample of 300-400 fish from each raceway was evaluated a minimum of 14 days after tagging for tag retention. The first adult returns of summer steelhead to the Umatilla River from fish reared at Umatilla Hatchery occurred in 1993-94. Expanded numbers of returning adults were based on coded-wire-tag returns to Three Mile Falls Dam and sport catch in the Umatilla River, Future recovery data will include Umatilla River returns plus data from the Columbia River and ocean fisheries.

Spring Chinook Salmon Subyearling and Yearling Production Evaluation

Rearing Performance

The methods used to monitor spring chinook salmon subyearling and yearling rearing performance are the same as those described for fall chinook salmon with the exception of the system comparisons. Spring chinook salmon yearlings from Bonneville hatchery were not monitored on a monthly basis.

Smolt Condition

We monitored the smolt condition of Umatilla reared spring chinook salmon in the same manner as for fall chinook salmon except that no physiological stress tests were conducted and no system comparisons were made. Gill ATPase levels were analyzed as per the methods described for 1992 brood spring chinook salmon. In addition, in 1994 we attempted to collect gills from actively migrating fish as they passed Three Mile Falls Dam. We used branded fish or length frequencies to positively identify actively migrating fish. Pre-release data was collected at Umatilla Hatchery or at upriver acclimation ponds.

Smolt Migration Performance

Smolt migration success, migration rate, and the duration of migration were compared for spring chinook salmon subyearlings and yearlings reared at Umatilla Hatchery and for yearlings reared at Bonneville Hatchery in the same manner as for fall chinook salmon. In 1994. six groups of 10.000 subyearlings and four groups of 5.000 yearlings were freeze-branded at Umatilla Hatchery to identify fish reared in each raceway. At Bonneville Hatchery, two groups of 5,000 yearlings were also branded.

Smolt-to-Adult Survival

In the future we will compare smolt-to-adult survival rates between groups of yearlings reared at Umatilla and Bonneville Hatcheries and subyearlings reared at Umatilla Hatchery. In addition, we will compare subyearling survival with expected values. In 1994 we marked approximately 50,000 subyearlings from each of six raceways with AD+CWT. We marked approximately 20,000 yearlings from two raceways at Bonneville and six raceways at Umatilla Hatchery with AD+CWT. To assure accuracy of tagging, a subsample of 300-400 fish from each raceway was checked for tag retention a minimum of 14 days after tagging.

Bonneville Hatchery Salmon Evaluation

In the future we will determine smolt-to-adult survival for fall chinook salmon yearling smolts and for spring chinook salmon released in the fall and reared at Bonneville Hatchery in the same manner as described for fall chinook salmon. To identify fish in each raceway in 1993-94 we Ad+CWT marked approximately 20,000 fall chinook salmon yearlings from two raceways. No spring chinook salmon for fall release were produced in 1993-94.

Effects of Tagging and Marking on Subyearling Fall Chinook Salmon

In 1992 and 1993 fall chinook salmon subyearlings from Umatilla Hatchery were marked to study the effects of tagging and marking and to determine the effectiveness of using blank-wire-tags implanted in the shoulder of fish as a mass marking tool (Keefe et al. 1993). Replicate groups of 70.000 salmon from two Oregon ponds were marked as follows: left ventral clip (LV), left ventral clip plus body tag (LV-BT), body tag only (BT), and adipose (AD)-right ventral (RV) plus CWT. We will compare smolt-to-adult return rates based on future recoveries at Three Mile Dam and other collection sites in the Columbia River Basin (Figure 1). Effects of different marks will be based on the following comparisons:

1. BT versus LV.
2. BT+LV versus BT to evaluate the effect of a ventral clip.
3. BT+LV versus LV to evaluate the effect of the body tag.
4. AD+LV+CWT versus LV to evaluate the effect of the adipose clip and coded-wire-tag.

Tag retention checks were conducted on both coded-wire-tagged and body tagged fish a minimum of 14 days after tagging.

A small number of body-tagged fish returned to the Umatilla River in fall 1993. To determine if fish carried body tags, fish were examined with a Northwest Marine Technologies field detector at Three Mile Falls Dam or at the Minthorn Acclimation Facility after the fish had been spawned.

Creel Survey

The primary goals of the Umatilla creel survey are 1) to identify recreational fishing areas that are used for fall Chinook salmon, spring chinook salmon, and summer steelhead; 2) to develop and implement statistical methods to estimate total effort, total catch, total harvest, and number harvested by tag code for fall chinook salmon, spring chinook salmon, and summer steelhead recreational fisheries; and 3) to coordinate with the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in their development of a monitoring program for tribal fisheries. The coded-wire-tag returns in this report are from fish reared in hatcheries other than Umatilla Hatchery and stocked into the Umatilla River. Fish were first released from Umatilla Hatchery in 1992 and the 1993-94 angling season was the first season anglers were likely to encounter adult returns from Umatilla Hatchery reared fish. We did not collect any snouts from 1991 brood year fish during 1993-94.

Because of the split fishing seasons. the 1993-1994 creel surveys on the Umatilla River were divided into three separate surveys:

1) Fishery: coho salmon and fall chinook salmon Jacks (16-24 inches)
Date: 1 October to 30 November, 1993
Boundary: Stanfield Dam downstream to Highway 730

2) Fishery: summer steelhead
Date: 1 December 1993 to 15 April, 1994
Boundary: The lower boundary of the CTUIR reservation downstream to Highway 730

3) Fishery: spring chinook salmon
There was no spring chinook salmon fishery in 1994 because of low numbers of returning adults.

For the 1993-94 creel season there were several changes made to the survey methods described in the 1992 annual report (Keefe et al. 1993). Because of high fishing pressure, we extended the lower boundary from the Highway 730 bridge to the mouth of the Umatilla River during the second half of the fall chinook salmon and coho salmon fishery. In addition, we randomly selected the first angler effort count from a choice of three starting times instead of four. We divided the available fishing hours into three equal periods with the first count falling within the first period. Subsequent counts were 3.5 - 4.5 hours after the previous count and fell within the 2nd and 3rd periods. The count schedule for the summer steelhead fishery was conducted in this manner also. We conducted periodic spot checks for anglers between Three Mile Falls Dam and Stanfield Dam as stated in the 1993 annual report (Keefe et al. 1994). Additional modifications to the summer steelhead fishery were also made in the 1993-94 creel survey. We switched from two 5 hour split shifts (10 hours split between the upper and lower sections) to one 10 hour shift per section. We spent fewer days in each section but were able to contact more anglers on each day. This permitted us to calculate daily variance estimates.

For the 1993-94 creel season we upgraded our data collection methods by utilizing handheld data recorders. We modified the summer steelhead program used for the Grande Ronde creel survey (written by Phil Flanders, Oregon Department of Fish and Wildlife, Marine Region). The statistical analysis methods used in 1993-94 were the same as described in the 1992 annual report (Keefe et al. 1993).

Statistical Analyses

The majority of tests comparing parameters between Michigan and Oregon systems and between passes within each system were analyzed using t-tests and analysis of variance (ANOVA). When applicable we used a nested ANOVA to separate sources of variation within the Michigan and Oregon systems. A maximum of three nesting levels were used and were as follows:

First level - SYSTEM (e.g. Michigan Oregon)
Second level- RACEWAY (e.g. M2 03)
Third level - PASS (eg A. B. C)

The analysis of gill ATPase in spring chinook salmon included a date effect, a pass effect, and date-by-pass interaction factor. Tests to evaluate the stress response of fall and spring chinook salmon were conducted using a treatment effect (control or treatment). a system or pass effect, and a treatment-by-system or treatment-by-pass interaction effect. The proportion of descaled and partially descaled fish were tested using the Kruskall-Wallis and Wilcoxon non-parametric analyses. Differences between pairs of means were tested by the Wilcoxon method. To compare survival indices we used binomial tests. For tests run on all possible combinations we used an alpha level adjusted to 0.02 to clarify where significant differences existed (Sokal and Rohlf 1981). For tests comparing the Oregon and Michigan systems, we included only A and B raceways. Tests designed to examine differences within the Michigan system included A, B, and C raceways. The results of all other tests including planned comparisons of differences between means using the Sidak technique (Sokal and Rohlf 1981) were evaluated at an alpha level = 0.05.

RESULTS

Fish Cultural Practices

Fall Chinook Salmon

Egg source for the 1993 brood fall chinook salmon were Upriver Bright stock from Priest Rapids Hatchery and from the Umatilla River. Fall chinook salmon were ponded on February 11 in four Oregon raceways. Fish were then split into two Oregon raceways and six Michigan raceways in late March when they reached 182 fish/lb. The final split was in early April when fish were moved into four Oregon raceways and six Michigan raceways. Rearing conditions for the fall chinook salmon are described in Table 2. To standardize donor parentage for each treatment and control group, fish were split so that each Michigan and Oregon raceway received equal proportions from all egg-takes. The fish from the Michigan raceways were released on May 23, at 67 fish/lb. and the fish from the Oregon raceways were released on May 24, at 61 fish/lb. (Table 3). Egg-to-smolt survival estimates can be found in Table 4.

Spring Chinook Salmon

Fall Release: The source for the 1992 and 1993 broods of spring chinook salmon were Carson stock. Fish cultural practices for the 1992 brood are detailed in the 1993 annual report (Keefe et al. 1993). Information on the 1992 brood release in fall of 1993 can be found in Table 3. Egg-to-smolt survival can be found in Table 4.

Approximately 640,000 green eggs from the 1993 brood were received and incubated at 42.5 F for the first seven days. The incubation temperature was then lowered to 38 F. The fish were ponded into one Oregon raceway in February 1994 and split into two Oregon raceways in May when they reached 76 fish/lb. Fish were marked and tagged and then split into ten raceways in August of 1994. Approximately 392,000 fish will be released in November 1994.

Table 2. Rearing conditions for fish reared in Oregon and Michigan raceways at Umatilla. Irrigon, and Bonneville Hatcheries and released in the Umatilla River during 1993-1994. Conditions described are immediately prior to release from the hatchery.

Race-species, release strategy	Brood year	System	Maximum density (lb/ft^3)	Maximum loading factor (lb/gal/min)
		Umatilla Hatchery		
Fall Chinook salmon:				
Subyearlings	1993	Michigan	2.2-2.5	4.8-5.5
		Oregon	0.5-0.8	2.6-3.7
Spring Chinook salmon:				
Fall release	1992	Michigan	1.1-1.2	2.5-2.6
		Oregon	0.3-0.4	1.7-1.8
Subyearlings	1993	Michigan	2.1-2.5	4.6-5.5
Yearlings	1993	Oregon	0.9-1.1	4.6-5.4
Summer Steelhead:	1993	Michigan	3.8-4.6	8.4-10.1
		Irrigon Hatchery		
Summer Steelhead:	1993	Oregon	1.4-1.5	6.7-7.4
		Bonneville Hatchery		
Fall Chinook salmon:				
Yearlings	1992	Oregon	0.8-1.2	6.6-7.9
Spring Chinook salmon:				
Yearlings	1992	Oregon	0.8-1.0	6.8-9.8

Table 3. Pre-release information for salmon and steelhead reared at Umatilla and Bonneville hatcheries and released into the Umatilla River during 1993-1994.

Race-species, Release strategy, system	Brood year	Date released	Number released[a]	Mean fork length (mm)	Mean weight (g)	Release location
		Umatilla Hatchery				
Fall chinook salmon:						
Subyearlings	1993					
Michigan		23 May 1994	1,901,441	82.4	6.8	UmR mi 74
Oregon		24 May 1994	941,771	85.3	7.4	UmR mi 74
Spring chinook salmon:						
Fall release	1992					
Oregon		17 Nov 1993	164,295	123.3	24.2	UmR mi 80
Michigan		17 Nov 1993	296,514	118.0	22.0	UmR mi 80
Yearlings	1992					
Oregon		21-22 Mar 1994	205,143	163.4	53.7	UmR mi 80[b]
Subyearlings	1993					
Michigan		20 May 1994	839,377	110.3	14.9	UmR mi 80[b]
Summer steelhead:	1993					
Michigan		12 May 1994	52,097	205.9	87.2	Bonifer
Michigan		14 Apr 1994	49,598	198.3	88.9	Minthorn
Michigan		11 Apr 1994	51,403	214.2	92.6	Bonifer
		Bonneville Hatchery				
Fall chinook salmon:						
Yearlings	1992					
Oregon		22-23 Mar 1994	233,629	158.0	45.8	UmR mi 74
Oregon		19 Apr 1994	49,824	159.8	47.7	UmR mi 74
Spring chinook salmon:						
Yearlings:	1992					
Oregon		24-25 Mar 1994	405,102	143.0	35.0	UmR mi 80

[a] *Numbers released based on coded-wire-tag reports.*
[b] *Acclimated and released from the Imeques C-Mem-Ini-Ken acclimation facility.*

Table 4. Egg-take and survival of salmon and steelhead reared at Umatilla Hatchery during 1993-1994.

Race-species. Release strategy, egg source	Brood year	Number of eggs taken or received	Egg-to-fry survival (%)	Egg-to-smolt[a] survival (%)
Fall chinook salmon:				
Subyearlings				
Priest Rapids	1993	3,181,000	81.7	
Umatilla	1993	352,000	76.1	
Total		3,533,000	81.1	80.4
Spring chinook salmon:				
Yearling:				
Carson	1992	319,000	71.3	67.4
Fall release				
Carson	1992	640.000	83.4	72.0
Subyearling:				
Carson	1993	1,100,000	80.1	76.4
Summer steelhead:				
Umatilla	1993	255,000	73.7	60.0

[a] *Survival estimate is based on green egg-to-smelt stage.*

Spring Release Yearlings: Approximately 352,000 green eggs from the 1993 brood year yearling program were incubated using the same process as for 1993 spring chinook salmon released in the fall. Fry were placed into indoor Canadian troughs then transferred into two Oregon raceways in April and May of 1994. In late August, these fish were split into four Oregon raceways and two Michigan raceways. Another group of production spring chinook salmon yearlings (Carson Stock) will also be reared at Bonneville Hatchery. Both groups of fish will be released in the spring of 1995. Information for the 1992 brood year spring releases that occurred in 1993 can be found in Table 3. Egg-to-smolt survival estimates can be found in Table 4.

Spring Release Subyearlings: The source for 1993 brood year spring chinook salmon was Carson stock. Approximately 1.1 million green eggs were transferred to Umatilla Hatchery (Table 4). Fish were ponded into one Oregon raceway in mid-November. Fish were split into two Oregon raceways in late December at about 250 fish/lb. In early February 1994 all of the fish were removed from the Oregon raceways and split into three Michigan raceways at 90 fish/lb. The final split was completed in late March when the fish were transferred to six Michigan raceways. Fish were ponded and split so that each Michigan raceway received equal proportions of fry from all egg-takes at the Carson Hatchery. This ensured that the donor parentage for each treatment and control was equal. Rearing conditions are described in Table 2 and release information described in Table 3.

Summer Steelhead

The 1993 brood stock for summer steelhead were Umatilla River stock. Approximately 255,000 green eggs were taken to Umatilla hatchery for incubation at 52 F (Table 4). Approximately 180,000 fry were ponded into indoor tanks then moved into one Oregon raceway in August 1993 at 256 fish/lb. They were split into two Oregon raceways in October 1993 at 89.6 fish/lb. In early November they were graded and split into three Michigan raceways (M5A, M5B, and M5C) at 39.6 fish/lb, 26.2 fish/lb, and 18.5 fish/lb respectively. Rearing conditions for summer steelhead are described in Table 2. Release information and egg-to-smolt survival estimates for summer steelhead can be found in Tables 3 and 4. respectively.

Water Quality Monitoring

Comparisons of Oregon and Michigan Systems

We found few significant differences in water quality parameters for fish reared in Michigan and Oregon systems (Table 5). The highest individual temperature observed in an individual raceway was 14.7 °C during the summer for an Oregon raceway that contained spring chinook salmon. The lowest individual measurement was 9.3 °C in a Michigan raceways for fall chinook salmon. There was a significant difference in mean pH between Oregon and Michigan systems (both head and tail) for fall chinook salmon but not for spring chinook salmon released in the fall. During the sampling period, the minimum individual pH measurement was 5.6 and the maximum individual measurement was 8.3. Mean water quality data for the other groups of fish is presented in Table 6.

The minimum oxygen level observed during a single sampling period was 5.8 ppm and the maximum level was 15.5 ppm in Michigan system raceways. Mean oxygen levels were within acceptable limits and typically declined 1.0 to 3.0 ppm from head to tail, in both rearing systems. The minimum individual nitrogen reading was 507 mmHG and the maximum was 773 mmHG. Minimum individual total gas pressure was 686 mmHg, the maximum was 837 mmHG. The lowest individual alkalinity value was 107 mg/L ($CaCO_3$), and the maximum was 173 mg/L ($CaCO_3$). Comparisons of mean unionized ammonia between Michigan and Oregon systems were not significantly different. For all raceways mean NH3 levels ranged from 0.36 to 2.16 ug/L.

Within Michigan System Comparisons

There were no significant differences between passes for any of the water quality parameters that were measured (Table 7). We observed that pH levels declined but unionized ammonia increased from the 1st pass to the 3rd pass raceways. Within a pass the nitrogen levels increased from head to tail.

Weekly oxygen levels ranged from a minimum of 5.9 ppm to a maximum of 17.5 ppm. The minimum individual unionized ammonia level was 0.13 ug/l in a 1st pass summer steelhead raceway and the maximum was 11.8 ugll in a 2nd pass summer steelhead raceway.

Table 5. Comparisons of water quality parameters in Oregon and Michigan systems during 1993-1994. Means are combined values for first and second pass raceways (* = significant difference between systems, Pr0.05; ns= no significant difference, Student's t-test).

Race-species, parameter measured	Mean parameter value (N) Oregon	Michigan	t-test
Fall chinook salmon:			
Temperature Head (°C)	**11.8** (16)	**11.7** (16)	**ns**
Temperature Tail (°C)	**11.9** (16)	**11.8** (16)	**ns**
pH **Head**	**8.0** (14)	**7.8** (14)	*
pH **Tail**	**7.9** (14)	**7.8** (14)	*
Oxygen Head (ppm)	**10.4** (16)	**12.7** (16)	*
Oxygen Tail (ppm)	**9.3** (16)	**9.4** (16)	**ns**
Nitrogen Head (mmHg)	**610** (16)	**574** (16)	*
Nitrogen Tail (mmHg)	**631** (16)	**614** (16)	**ns**
Total Pressure-Head (mmHg)	762 (16)	**757** (16)	**ns**
Total Pressure-Tail (mmHg)	767 (16)	**752** (16)	**ns**
Unionized ammonia (µg/l)	0.36 (8)	**0.56** (7)	ns
Alkalinity (mg/l $CaCO_3$)	**143** (8)	**143** (8)	**ns**
Spring chinook[a]:			
Temperature Head (°C)	**14.2** (28)	**14.1** (28)	**ns**
Temperature Tail (°C)	**14.4** (28)	**14.1** (28)	*
pH **Head**	**7.9** (22)	**7.4** (22)	**ns**
pH **Tail**	**7.9** (21)	**7.8** (22)	**ns**
Oxygen Head (ppm)	**9.8** (28)	**10.4** (28)	*
Oxygen Tail (ppm)	**8.9** (28)	**9.5** (28)	*
Nitrogen Head (mmHg)	**607** (28)	**599** (28)	**ns**
Nitrogen Tail (mmHg)	**624** (28)	**606** (28)	*
Total Pressure-Head (mmHg)	757 (28)	**753** (28)	**ns**
Total Pressure-Tail (mmHg)	758 (28)	**752** (28)	**ns**
Unionized ammonia (µg/l)	1.54 (12)	**1.30** (12)	ns
Alkalinity (mg/l $CaCO_3$)	**144** (12)	**143** (12)	**ns**

[a] *Will be released in November 1994 (1993 brood)*

Table 6. Water quality parameters in Michigan or Oregon raceways during 1993-1994.

Race-species, parameter measured	Mean parameter value (N) Oregon	Michigan
Spring chinook salmon subyearlings:		
Temperature Head (°C)		11.2 (33)
Temperature Tail (°C)		11.3 (32)
pH Head		7.8 (33)
pH Tail		7.6 (32)
Oxygen Head (ppm)		12.4 (33)
Oxygen Tail (ppm)		10.0 (32)
Nitrogen Head (mmHg)		599 (33)
Nitrogen Tail (mmHg)		636 (33)
Total Pressure-Head (mmHg)		773 (33)
Total Pressure-Tail (mmHg)		779 (33)
Unionized ammonia (μg/l)		0.62 (15)
Alkalinity (mg/l CaCO3)		142 (15)
Spring chinook salmon yearlings:		
Temperature Head (°C)	12.8 (66)	
Temperature Tail (°C)	12.9 (66)	
pH Head	7.8 (64)	
pH Tail	7.8 (64)	
Oxygen Head (ppm)	10.2 (66)	
Oxygen Tail (ppm)	9.0 (66)	
Nitrogen Head (mmHg)	627 (66)	
Nitrogen Tail (mmHg)	646 (66)	
Total Pressure-Head (mmHg)	779 (66)	
Total Pressure-Tail (mmHg)	781 (66)	
Unionized ammonia (μg/l)	0.89 (33)	
Alkalinity (mg/l CaCO3)	137 (33)	
Summer steelhead (1993-1994)		
Temperature Head (°C)		12.0 (62)
Temperature Tail (°C)		12.0 (62)
pH Head		7.7 (59)
pH Tail		7.6 (59)
Oxygen Head (ppm)		13.2 (62)
Oxygen Tail (ppm)		10.5 (62)
Nitrogen Head (mmHg)		584 (62)
Nitrogen Tail (mmHg)		619 (62)
Total Pressure-Head (mmHg)		775 (62)
Total Pressure-Tail (mmHg)		773 (62)
Unionized ammonia (μg/l)		2.16 (30)
Alkalinity (mg/l CaCO3)		132 (30)

Table 7. Comparisons of water quality parameters between first. second, and third pass Michigan raceways during 1993-1994. Parameter means with similar letters or without letters are not significantly different (ANOVA, P>0.05).

Race-species, parameter measured	N	Mean parameter value 1st pass	2nd pass	3rd pass
Fall chinook salmon:				
Temperature Head (°C)	8	11.5	11.9	11.9
Temperature Tail (°C)	8	11.7	11.9	12.0
pH Head	7	7.9	7.8	7.7
pH Tall	7	7.8	7.8	7.6
Oxygen Head (ppm)	8	12.4	12.9	12.4
Oxygen Tail (ppm)	8	9.5	9.3	9.6
Nitrogen Head (mmHg)	8	579	568	572
Nitrogen Tail (mmHg)	8	613	615	609
Pressure-Head (mmHg)	8	758	756	754
Pressure-Tail (mmHg)	8	751	753	751
Unionized ammonia (µg/l)	4	0.37	0.76	0.76
Alkalinity (mg/l CaCO3)	4	142	143	144
Spring chinook salmon (released Nov 1994):				
Temperature Head (°C)	14	14.7	14.1	14.3
Temperature Tail (°C)	14	14.1	14.2	14.3
pH Head	11	80	7.9	7.9
pH Tail	11	7.8	7.9	7.9
Oxygen Head (ppm)	14	10.2	11.0	11.0
Oxygen Tail (ppm)	14	9.4	9.7	10.1
Nitrogen Head (mmHg)	14	601	590	590
Nitrogen Tail (mmHg)	14	609	598	598
Pressure-Head (mmHg)	14	750	602	757
Pressure-Tail (mmHg)	14	752	757	753
Unionized ammonia (µg/l)	6	1.00	1.59	2.03
Alkalinity (mg/l CaCO3)	6	143	143	143
Spring chinook salmon (subyearlings):				
Temperature Head (°C)	11	11.2	11.1	11.3
Temperature Tail (°C)	11(10)[a]	11.3	11.2	11.3
pH Head	11	7.8	7.8	7.7
pH Tail	11(10)	7.8	7.5	7.6
Oxygen Head (ppm)	11	12.8	11.9	12.5
Oxygen Tail (ppm)	11(10)	10.3	9.8	9.8
Nitrogen Head (mmHg)	11	589	603	604
Nitrogen Tail (mmHg)	11	629	638	640
Pressure-Head (mmHg)	11	773	775	773
Pressure-Tail (mmHg)	11	778	780	778
Unionized ammonia (µg/l)	5(4)	0.44	0.81	0.57
Alkalinity (mg/l CaCO3)	5	140	143	143

Table 7, continued

Race-species, parameter measured	N	Mean parameter value 1st pass	2nd pass	3rd pass
Summer steelhead:				
Temperature Head (°C)	24 (19)[b]	11.9	12.1	12.0
Temperature Tail (°C)	24 (19)	11.9	12.0	12.0
pH Head	23 (18)	7.7	7.7	7.6
pH Tail	23 (18)	7.7	7.6	7.5
Oxygen Head (ppm)	24 (19)	12.7	12.7	14.2
Oxygen Tail (ppm)	24 (19)	9.9	10.7	11.1
Nitrogen Head (mmHg)	24 (19)	592	590	568
Nitrogen Tail (mmHg)	24 (19)	629	615	609
Pressure-Head (mmHg)	24 (19)	776	775	774
Pressure-Head (mmHg)	24 (19)	774	772	772
Unionized ammonia (µg/l	12 (9)	0.9	2.4	3.5
Alkalinity (mg/l CaCO3)	12 (9)	134	131	131

[a] *Sample size for third pass raceway in parentheses.*
[b] *Sample size for second and third pass raceways in parentheses.*

Rearing Performance and Survival Studies

Fall Chinook Salmon

Rearing Performance: Fall chinook salmon reared in Michigan and Oregon raceways were ponded in March. From April until pre-release, Oregon reared showed greater increases in length and weight than Michigan reared fish (Tables 8 and 9). Fall chinook salmon reared in Oregon raceways were significantly better at converting food than fish reared in Michigan raceways (Table 10). Although fish in third pass raceways appeared to convert feed less efficiently, differences between fish from first, second, and third pass Michigan raceways were not significant (Table 10).

Smolt Condition: At release, Oregon reared fish were significantly longer and heavier than Michigan reared fish, but there was no significant difference in condition factor (Table 8). In Oregon raceways. fish from second pass raceways were larger than fish from first pass raceways prior to release (Table 9). Within Michigan passes, no trends in length or weight measurements were apparent; however, condition factor significantly declined from first to third pass raceways (Table 9).

The percentage of fall chinook salmon that were identified as smolts ranged from 32%-51% in Michigan raceways and 63%-72% in Oregon raceways. For first, second, and third pass Michigan raceways, percentages also ranged from 32%-51%. Most other fish were classified as intermediate smolts at pre-release. Fall chinook salmon reared in Michigan raceways suffered significantly more descaling than Oregon reared fish (Table 11) whereas fish reared in different Michigan passes suffered similar levels of descaling.

Table 8. Monthly and pre-release comparisons of mean length, weight, and condition factor for 1993 brood subyearling fall chinook salmon reared in Oregon and Michigan systems during 1994. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at P>0.05.

Month, system	Length (mm) N	Length (mm) Mean(SE)	Weight(g) N	Weight(g) Mean(SE)	Condition Factor N	Condition Factor Mean(SE)
March:						
Oregon	245	62.0(0.25)	118	2.6(0.05)	118	1.09(0.010)
Michigan	487	62.4(0.18)	255	2.5(0.03)	255	1.04(0.006)
April:						
Oregon	423	72.9(0.30)	220	4.5(0.09)	220	1.11(0.005)
Michigan	460	74.1(0.26)	194	4.6(0.08)	194	1.17(0.008)
Pre-release:						
Oregon	1366	85.3(0.16) a	433	7.4(0.08) a	433	1.18(0.005) a
Michigan	1270	82.4(0.19) b	437	6.7(0.08) b	437	1.18(0.005) a

Fall chinook salmon reared in Michigan and Oregon raceways responded to stress in a similar manner (Figure 3). We found no significant treatment-by-system interaction in the cortisol or glucose responses for tests conducted at the hatchery or at the release site. There were significant treatment effects at the hatchery and significant system effects at both test sites. In all comparisons, Oregon reared fish had greater glucose and cortisol levels than Michigan reared fish. For fish transported to the release site, no treatment effects from the standard stress were evident and response levels were similar to values obtained for fish subjected to the standard stress at the hatchery.

Fish reared in different Michigan passes also showed similar cortisol and glucose responses to the standard stress for tests conducted at the hatchery and at the release site (Figure 4). We found only one significant treatment by pass interaction in a hatchery cortisol test. For tests at the hatchery, the stress treatment described most of the observed variation and fish from all passes had greater cortisol levels after being subjected to the standard stress. Fish tested at the river showed no significant changes in cortisol or glucose levels after being stressed (Figure 4). In addition, cortisol values obtained from control fish at the release site were similar to values obtained from treatment fish at the hatchery. Glucose values showed few differences between any groups.

Table 9. Monthly and pre-release comparisons of mean length, weight, and condition factor for 1993 brood subyearling fall chinook salmon reared in first and second pass Oregon raceways and in first, second, and third pass Michigan raceways during 1994. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at $P>0.05$.

Month. raceway	Length (mm) N	Length (mm) Mean(SE)	Weight(g) N	Weight(g) Mean(SE)	ondition Factor N	ondition Factor Mean(SE)
			Oregon Raceways			
March:						
1st Pass	138	61.8(0.31)	67	2.5(0.06)	67	1.09(0.010)
2nd Pass	107	62.3(0.41)	51	2.6(0.07)	51	1.09(0.020)
April:						
1st Pass	219	71.4(0.51)	110	4.4(0.11)	110	1.08(0.008)
2nd Pass	204	74.4(0.43)	110	4.8(0.12)	110	1.13(0.007)
Pre-release:						
1st Pass	691	84.5(0.22) b	210	7.3(0.12) b	210	1.20(0.006) a
2nd Pass	675	86.2(0.22) a	223	7.6(0.09) a	223	1.17(0.007) b
			Michigan Raceways			
March:						
1st Pass	266	62.5(0.23)	128	2.4(0.04)	128	1.01(0.008)
2nd Pass	221	62.4(0.28)	127	2.6(0.05)	127	1.08(0.007)
3rd Pass	211	61.8(0.29)	141	2.5(0.06)	141	1.07(0.017)
April:						
1st Pass	219	72.4(0.34)	122	4.6(0.11)	122	1.18(0.010)
2nd Pass	241	75.7(0.36)	72	4.6(0.13)	72	1.12(0.013)
3rd Pass	261	75.8(0.35)	114	4.8(0.11)	114	1.10(0.008)
Pre-release:						
1st Pass	645	81.7(0.26) b	221	6.9(0.11) a	221	1.22(0.007) a
2nd Pass	625	83.2(0.26) a	216	6.7(0.11) a	216	1.15(0.006) b
3rd Pass	615	82.0(0.27) b	210	6.4(0.12) b	210	1.11(0.007) c

Table 10. Mean food conversion ratios for 1993 brood subyearling fall chinook salmon reared in Oregon and Michigan systems during 1994. Letters indicate statistical groupings for tests between systems or passes based on Wilcoxon or Kruskall-Wallis test. Means with the same letters are not significantly different at P>0.05.

System, raceway	N	Mean food conversion ratio (SE)
Oregon	4	0.95(0.02)a
Michigan	4[a]	1.13(0.03)b
1st Pass	2	1.14(0.05)x
2nd Pass	2	1.13(0.06)x
3rd Pass		1.53(0.04)x

[a] *Combined first and second pass raceways.*

Table 11. Comparison of the mean proportion of descaled. partially descaled, and undamaged 1993 brood subyearling fall chinook salmon reared in Oregon and Michigan systems during 1994 (SE in parentheses). Letters indicate statistical groupings for tests of descaled proportion between systems or passes based on Wilcoxon or Kruskall-Wallis test. Means with the same letters are not significantly different at P>0.05.

System, raceway	N	Descaled	Partially descaled	Undamaged	Groups
Oregon	4	0.00(0.00)	0.12(0.06)	0.88(0.06)	a
Michigan	4a	0.12(0.03)	0.54(0.07)	0.34(0.08)	b
1st Pass	2	0.17(0.01)	0.51(0.08)	0.32(0.08)	x
2nd Pass	2	0.08(0.01)	0.57(0.16)	0.35(0.17)	x
3rd Pass	2	0.04(0.02)	0.60(0.05)	0.36(0.03)	x

a Combined first and second pass raceways.

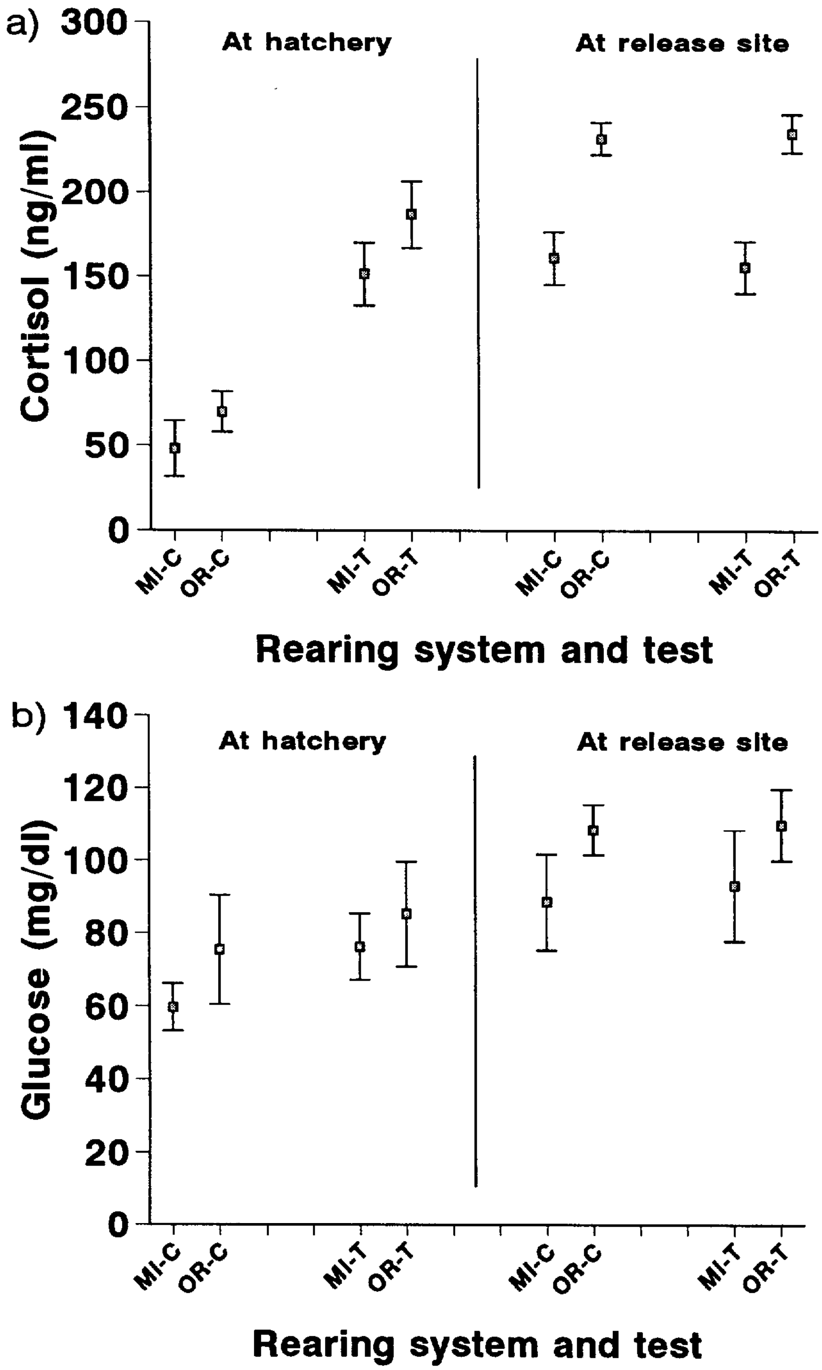


Figure 3. Mean a) plasma cortisol and b) plasma glucose levels for subyearling fall chinook salmon reared in Michigan and Oregon systems and subjected to a standardized stress in 1994. Tests at the release site represent values obtained immediately after transportation. (MI = Michigan system fish, OR = Oregon system fish; C = control fish, T = treatment fish subjected to the standard stress; n = approximately 18 for each mean, bars = 95% confidence intervals).

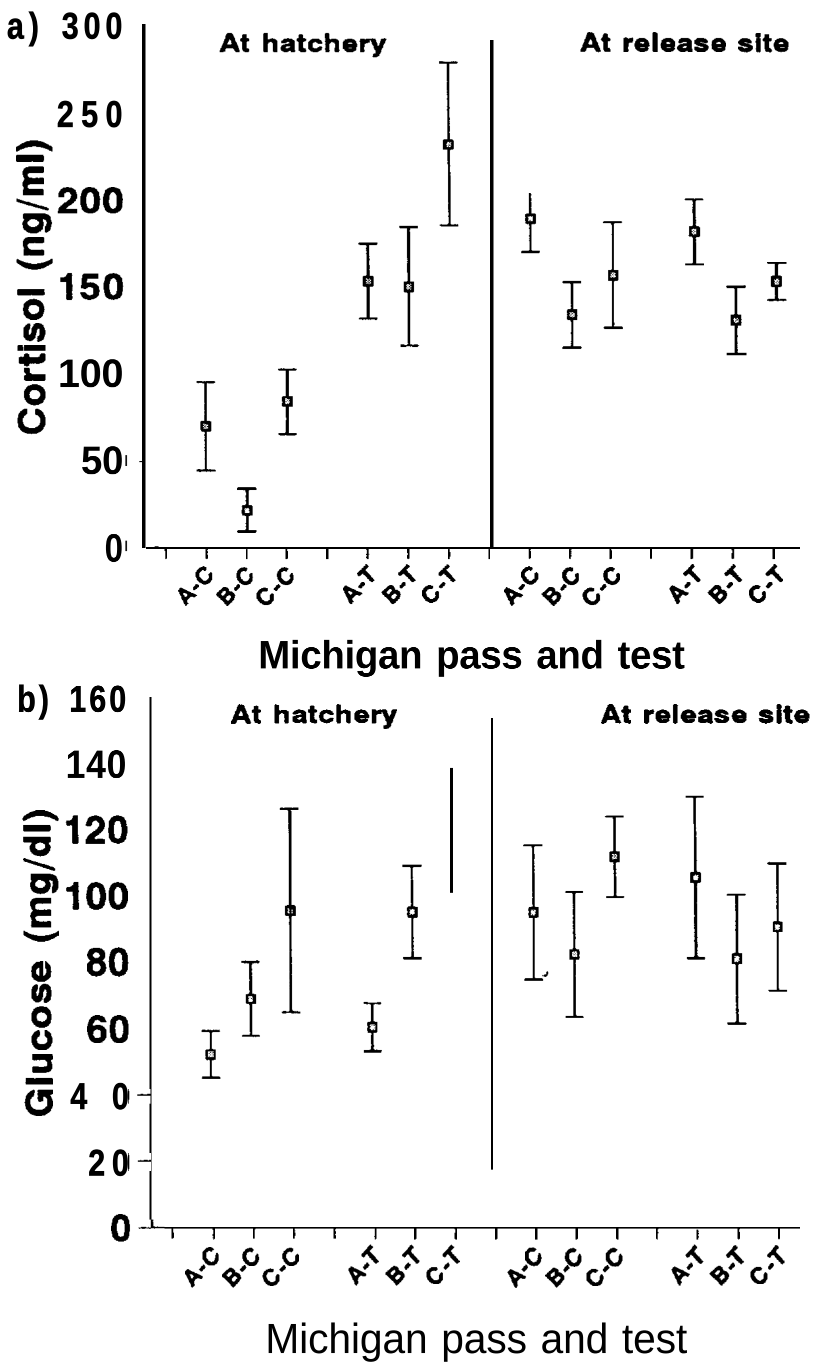


Figure 4. Mean a) plasma cortisol and b) plasma glucose levels for subyearling fall chinook salmon reared in Michigan system raceways and subjected to a standardized stress in 1994. Tests at the release site represent values obtained immediately after transportation. (First single letter indicates pass: A = first pass. B = second pass, and C = third pass raceways; second single letter indicates tests: C = control fish or T = treatment fish subjected to the standard stress, n = approximately 18 for each mean, bars = 95% confidence intervals).

Smolt Migration Performance: In 1994 the number of fish marked with readable brands ranged from 9,263 to 10,302 among raceways (Table 12). Numbers of branded fish collected at the John Day dam ranged from 9 to 20 for individual raceways. We found no significant difference in survival indices for Michigan and Oregon reared fish in 1994 (Table 13). Survival indices were significantly greater for Michigan reared fish from third and first pass raceways than for fish from second pass raceways (Table 13). Fish reared in second pass Oregon raceways survived at a greater rate than did fish from first pass Oregon raceways.

Table 12. Brand and coded-wire-tag information for 1993 brood subyearling fall chinook salmon marked at Umatilla Hatchery in 1994 (LOC = location of brand, POS = position of brand, RD = right dorsal, LD = left dorsal, RV = right ventral clip, CWT = coded-wire-tag).

System, Raceway	Number branded	Size	LOC	Brand	POS	Fin clip	Readable brands	CWT code	Number CWT[a]
Michigan									
2A	10,631	3/16"	LD	L	3	RV	10,171	070663	31,162
2B	10.222	3/16"	LD	L	4	RV	10,008	070720	30,528
2c	10.185	3/16"	LD	E	4	RV	9,769	070722	30,950
3A	10.302	3/16"	RD	L	3	RV	9,725	070719	31,658
3B	10,239	3/16"	RD	L	4	RV	10,217	070723	30.447
3c	10,208	3/16"	RD	E	4	RV	9,373	070721	28.474
Oregon									
2A	10.158	3/16"	RD	L	2	RV	9,263	070662	31,239
2B	10.906	3/16"	RD	L	1	RV	9.516	070716	30,502
3A	10,220	3/16"	LD	L	2	RV	9,769	070718	31.040
3B	10,260	3/16"	LD	L	1	RV	9,899	070717	32,481

[a] *Number recognizably coded-wire-tagged and released. All CWT fish are also adipose fin clipped.*

Table 13. Survival index for Umatilla Hatchery 1993 brood subyearling fall chinook salmon based on brand recoveries to the John Day Dam during spring 1994. Letters indicate statistical groupings for tests between systems or between passes within systems. Means with the same letter are not significantly different at P>0.05 (binomial test).

System' raceway	Survival index
Michigan[a]	1.5 a
1st pass	1.7 r
2nd Pass	1.2 s
3rd Pass	1.7 r
Oregon	1.6 a
1st Pass	1.5 x
2nd Pass	1.8 y

[a] *First and second pass raceways combined.*

Branded fall chinook salmon were released on 23 and 24 May 1994. The first branded fish were captured at the John Day Dam on June 11 and fish continued to be captured from some raceways until 21 July 1994. For all raceways, fifty-percent of the branded fish were recovered from 36 to 40 days after release (Figure 5).

Smolt-to-Adult Survival: The goal to recognizably coded-wire-tag 30.000 fall chinook salmon was reached in nine of ten raceways (Table 12). Tag retention ranged from 89.1% to 99.7% for all ten fall chinook salmon raceways.

Straying: More than 2,400,000 fall chinook salmon were right ventral clipped and marked in the snout with blank-wire-tags in 1994. Tag retention was greater than 97% for all groups. An average of 1.1% of the fish were poorly clipped and 1.9% of the fish were unclipped. Adult straying information from the first Umatilla Hatchery releases will be included in the 1995 annual report.

Spring Chinook Salmon Released in the Fall

Rearing Performance of the 1992 Brood Year: Spring chinook salmon from the 1992 brood were released in November 1993. Preliminary information on the 1992 brood was included in the 1993 annual report. Final food conversion ratios ranged from 1.91 in Oregon raceways to 2.53 in the Michigan raceways (Table 14). Food conversion ratios were significantly greater in Michigan than in Oregon raceways, although there was no significant differences between the Michigan passes.

Rearing Performance of the 1993 Brood Year: Monthly length, weight and condition factor data for spring chinook salmon to be released in fall 1994 is presented in Table 15. Pre-release and food conversion data for the 1993 brood will be presented in the 1995 annual report.

Fish reared in Michigan and Oregon raceways and tested at Umatilla Hatchery and the release site showed similar responses to the standard stress (Figure 6). The ANOVA model was significant in all tests except the glucose test at the release site and no system-by-treatment interaction was observed. When the ANOVA model was significant, most of the variation was explained by the standard stress (treatment). Significant system effects were observed in two of four tests with Michigan reared fish displaying elevated cortisol and glucose levels.

Fish from first, second, and third pass Michigan raceways had similar cortisol and glucose responses to the standard stress (Figure 7). In three of four experiments, our analysis showed no significant treatment-by-pass interactions for tests performed at the hatchery or at the release site. In the cortisol test at the hatchery where a significant interaction was observed, all groups showed an increased response to the standard stress. Third pass raceways could not be tested at the release site.

Trends in ATPase levels for spring chinook salmon reared in Michigan and Oregon raceways and released in the fall were similar in 1993. Although we found significant system and system by date interaction effects, most of the variation was explained by date. For fish reared in Michigan and Oregon raceways we observed declining ATPase levels from 4 October 1993 through release on 17 November 1993. Tests of ATPase for fish raised in Michigan passes also showed a significant date effect (Figure 8). ATPase levels generally declined as the release date was approached. Only fish from third pass raceways showed a significant increase at release.

Smolt-to-Adult Survival of the 1992 Brood Year: Approximately 35,000 of the 1992 brood spring chinook salmon were marked Ad+CWT marked in each raceway in 1993 (Table 19). Tag retention ranged from 92.1% to 99.0%.

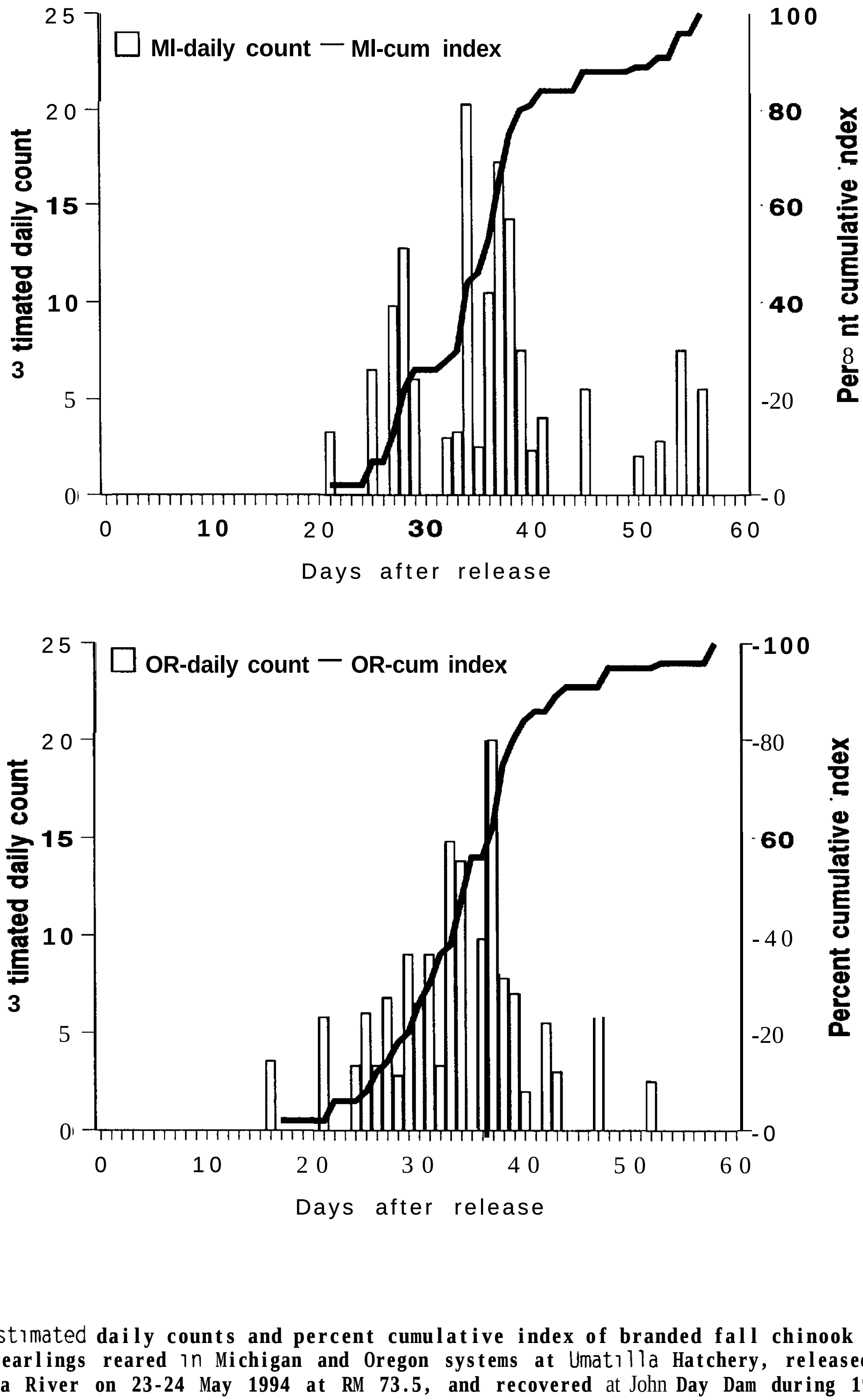


Figure 5. Estimated daily counts and percent cumulative index of branded fall chinook salmon subyearlings reared in Michigan and Oregon systems at Umatilla Hatchery, released in the Umatilla River on 23-24 May 1994 at RM 73.5, and recovered at John Day Dam during 1994.

Table 14. Mean food conversion ratios for 1992 brood spring chinook salmon reared in Oregon and Michigan raceways and released in the fall 1993. Letters indicate statistical groupings for tests between systems or passes based on Wilcoxon or Kruskall-Wallis test. Means with the same letters are not significantly different at P>0.05.

System, raceway	N	Mean food conversion ratio (SE)
Oregon	4	1.91(0.03)b
Michigan	4[a]	2.42(0.04)a
1st Pass	2	2.42(0.08)x
2nd Pass	2	2.42(0.06)x
3rd Pass	2	2.53(0.24)x

[a] *Combined first and second pass raceways.*

Table 15. Monthly comparisons of mean length, weight, and condition factor for 1993 brood spring chinook salmon reared in Oregon and Michigan system raceways and released in the fall 1994.

Month,	Length (mm)		Weight(g)		ondition Factor	
system	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
June:						
Oregon	239	101.8 (0.44)	105	12.6 (0.25)	105	1.2 (0.009)
July:						
Oregon	204	117.7 (0.68)	110	21.1 (0.50)	110	1.2 (0.011)
Michigan	228	113.1 (0.61)	142	18.9 (0.36)	142	1.3 (0.009)
August:						
Oregon	443	128.3 (0.74)	213	28.9 (0.64)	213	1.3 (0.008)
Michigan	463	123.6 (0.74)	222	28.0 (0.71)	222	1.4 (0.007)
September:						
Oregon	415	150.2 (0.99)	216	44.4 (1.05)	216	1.3 (0.008)
Michigan	435	133.2 (1.00)	213	34.4 (1.08)	213	1.4 (0.009)

Table 16. Pre-release comparisons of mean length, weight, and condition factor for 1992 brood spring chinook salmon reared in Michigan and Oregon system raceways and released in the fall 1993. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at P>0.05.

	Length (mm)		Weight(g)		Condition Factor	
System	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
Michigan	1247	118.0(0.24)a	421	22.0(0.25)a	421	1.32(0.004)a
Oregon	1232	123.3(0.25)b	430	24.2(0.27)a	430	1.27(0.005)b

Table 17. Monthly and pre-release comparisons of mean length, weight, and condition factor for 1992 brood spring chinook salmon reared in Michigan and Oregon system raceways and released in the fall 1993. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at P>0.05.

Month,	length (mm)		Weight(g)		Condition Factor	
raceway	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
			Oregon			
September:						
1st pass	225	105.6(0.38)	106	16.0(0.28)	106	1.36(0.015)
2nd pass	229	105.5(0.39)	117	15.6(0.24)	117	1.30(0.008)
October:						
1st pass	218	114.0(0.53)	110	20.1(0.44)	110	1.32(0.007)
2nd pass	249	114.0(0.47)	108	19.9(0.40)	108	1.32(0.007)
Pre-release:						
1st pass	600	121.7(0.34)b	210	24.3(0.38)a	210	1.32(0.005)a
2nd pass	632	124.8(0.35)a	220	24.1(0.39)a	220	1.23(0.007)b
			Michigan			
September:						
1st pass	207	103.4(0.44)	206	15.7(0.25)	206	1.40(0.014)
2nd pass	212	104.1(0.43)	117	15.6(0.26)	117	1.34(0.018)
3rd pass	223	105.3(0.39)	116	14.9(0.25)	116	1.28(0.008)
October:						
1st pass	218	114.0(0.50)	110	20.1(0.44)	110	1.33(0.007)
2nd pass	249	114.0(0.41)	108	19.9(0.41)	108	1.32(0.007)
3rd pass	211	113 8(0.55)	105	20.4(0.41)	105	1.35(0.009)
Pre-release:						
1st pass	619	117.9(0.36)a	214	22.1(0.37)a	214	1.31(0.006)a
2nd pass	628	118.1(0.32)a	207	21.9(0.34)a	207	1.33(0.005)a
3rd pass	611	118.6(0.33)a	202	22.3(0.34)a	202	1.32(0.005)a

Table 18. Comparison of the mean proportion of descaled. partially descaled. and undamaged 1992 brood spring chinook salmon reared in Oregon and Michigan systems and released in the fall 1993 (SE in parentheses). Letters indicate statistical groupings for tests of descaled proportion between systems or passes based on Wilcoxon or Kruskall-Wallis test. Means with the same letters are not significantly different at $P>0.05$.

System, raceway	N	Descaled	Partially descaled	Undamaged
Oregon	4	0.00(0.00)	0.09(0.03)	0.91(0.07) **a**
Michigan	4[b]	0.05(0.01)	0.34(0.06)	0.61(0.06) **b**
1st Pass	2	0.05(0.02)	0.24(0.05)	0.70(0.04) **x**
2nd Pass	2	0.06(0.01)	0.44(0.04)	0.51(0.06) **x**
3rd Pass	2	0.05(0.01)	0.41(0.05)	0.54(0.05) **x**

[a] *Combined first and second pass raceways.*

Table 19. Coded-wire-tag and fin clip information for 1992 brood spring chinook salmon marked at Umatilla Hatchery and released in the fall 1993 (LV = left ventral clip, CWT = coded-wire-tag).

System, raceway	Fin clip	CWT code	Number CWT[a]
Michigan			
2A	ADLV	070159	34,541
2B	ADLV	070161	35,657
2c	ADLV	070216	36,102
3A	ADLV	070160	35,408
3B	ADLV	070163	35,467
3c	ADLV	070163	36,157
Oregon			
2A	ADLV	070155	35,710
2B	ADLV	070157	34,857
3A	ADLV	070156	33,999
3B	ADLV	070158	34,130

[a] *Number coded-wire tagged and recognizably released in November 1993, all CWT fish are also adipose fin clipped.*

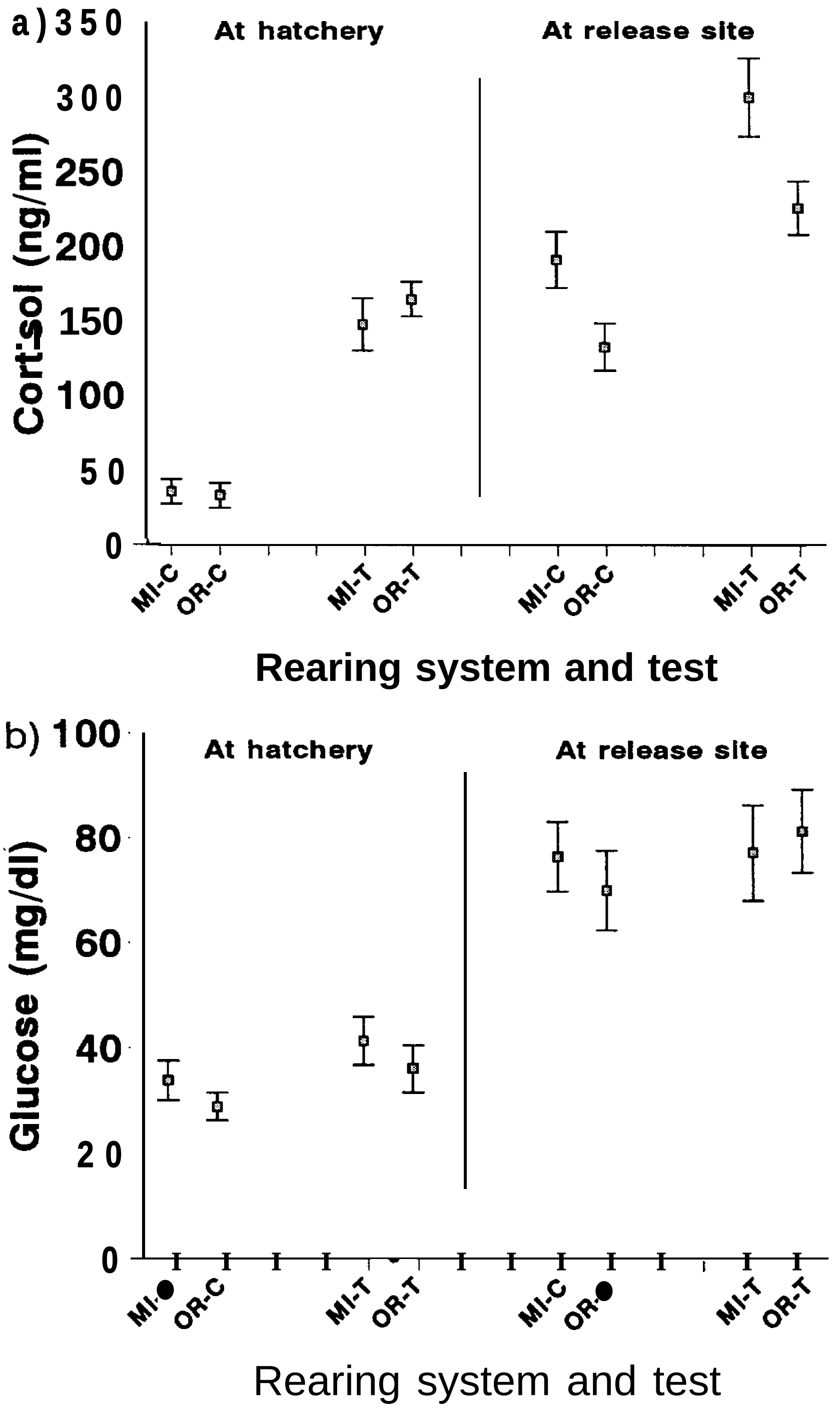


Figure 6. Mean a) plasma cortisol and b) plasma glucose levels for spring chinook salmon reared in Michigan and Oregon systems, subjected to a standardized stress, and released in fall 1993. Tests at the release site represent values obtained immediately after transportation. (MI = Michigan system fish, OR = Oregon system fish; C = control fish. T = treatment fish subjected to the standard stress; n = approximately 12 for each mean. bars = 95% confidence intervals).

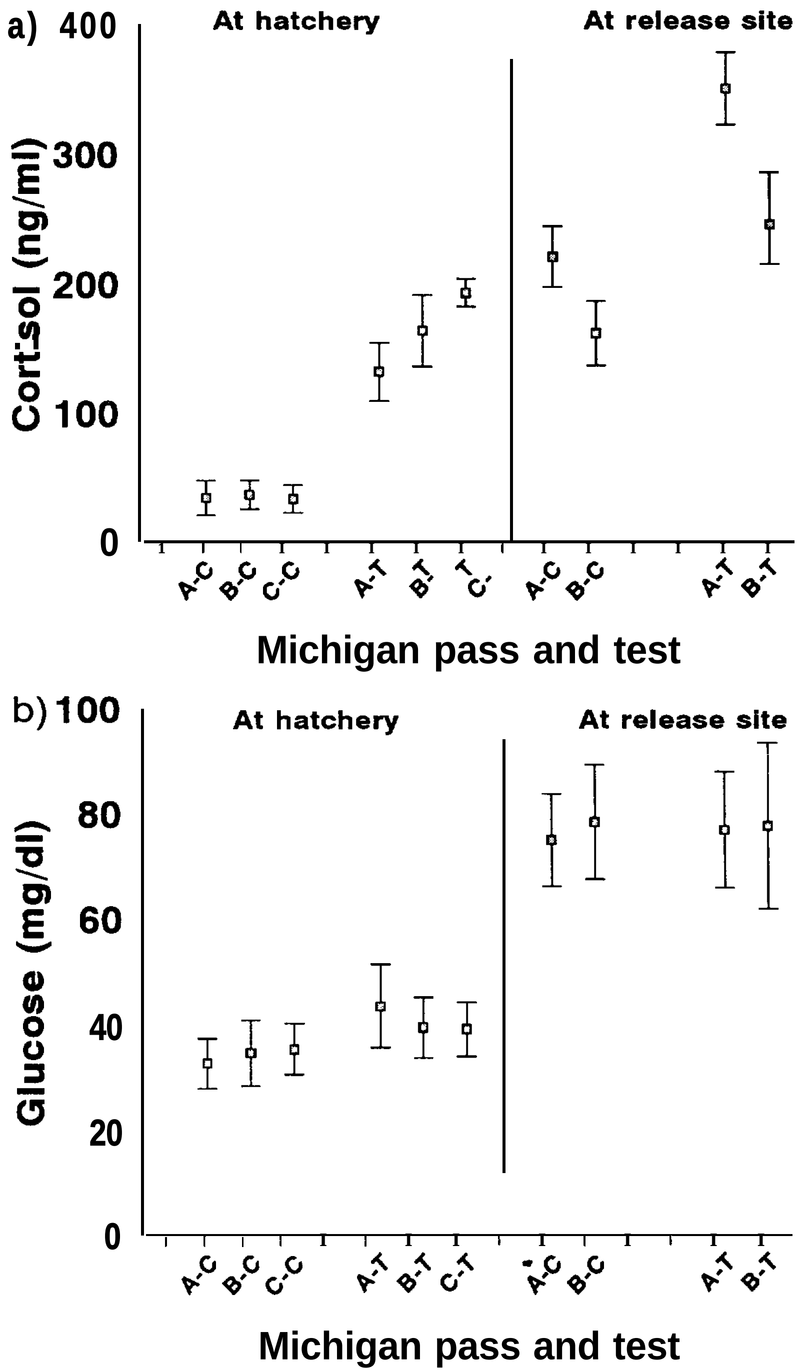


Figure 7. Mean a) plasma cortisol and b) plasma glucose levels for spring chinook salmon reared in Michigan system raceways, subjected to a standardized stress, and released in fall 1993. Tests at the release site represent values obtained immediately after transportation. (First single letter indicates pass. A = first pass, B = second pass. and C = third pass raceways; third single letter indicates C = control fish or T = treatment fish subjected to the standard stress, n = approximately 12 for each mean, bars = 95% confidence intervals).

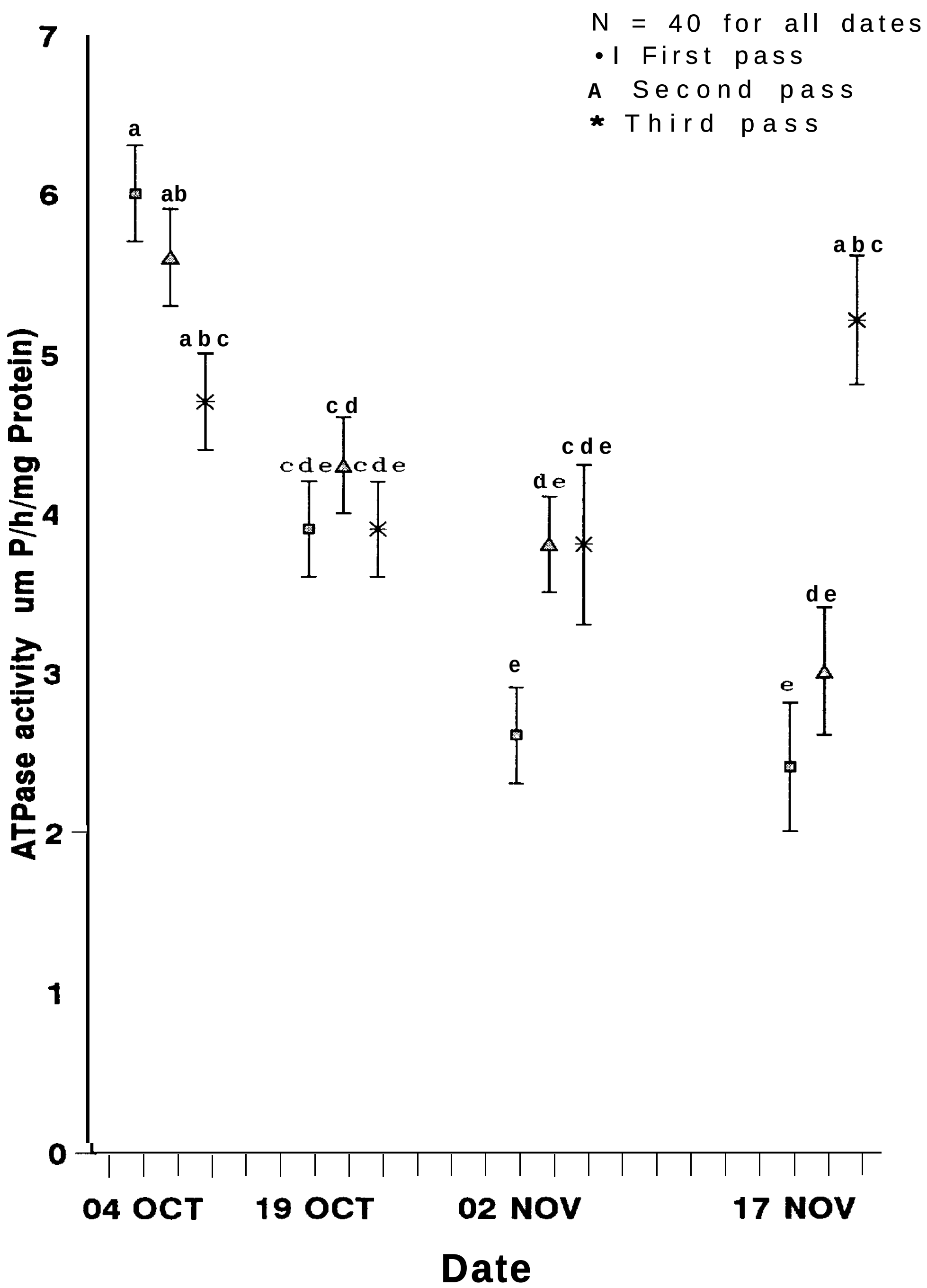


Figure 8. Gill ATPase specific activity (μm P/h/mg protein) in 1992 brood spring chinook salmon released in the fall 1993 Tests were conducted prior to release and at release. Bars = 95% confidence intervals. Means with similar letters are not significantly different, Sidak multiple comparison test P>0.05.

Smolt Condition of the 1992 Brood Year: Pre-release data for 1992 brood spring chinook salmon was obtained in November 1993 (Tables 16 and 17). Although fish reared in Oregon raceways were significantly longer than fish reared in Michigan raceways, there was no significant difference in mean weight. Michigan reared fish had a significantly higher condition factor and sufffered significantly more descaling and partial descaling than Oregon reared fish (Table 18). No more than 5% of the spring chinook salmon released in the fall from Michigan and Oregon raceways were classified as smolts at pre-release and most fish were classified as intermediate smolts. No significant differences were in mean length, weight, condition factor, or degree of smoltification for fish reared in different Michigan passes.

Smolt-to-Adult Survival of the 1993 Brood Year: More than 35,000 1993 brood spring chinook salmon from each raceway were Ad+CWT marked in August 1994. Final coded-wire-tag data for the 1993 brood will be available in the 1995 annual report.

Spring Chinook Salmon Subyearlings

Michigan versus Oregon tests of spring chinook salmon subyearlings were conducted in 1992, only. Adult return data will be presented in future reports as this information becomes available.

Summer Steelhead

Rearing Performance: Because fish were graded before ponding, length, weight. and condition factors were monitored but not tested (Table 20). The largest fish were reared in the third pass raceway and the smallest fish were reared in the first pass raceway. Mean dry food conversion ratios were similar for summer steelhead reared in different Michigan raceways (Table 21). In comparison to steelhead raised at Irrigon Hatchery first pass raceways, steelhead at Umatilla Hatchery were poorer at converting food.

Smolt Condition: Pre-release length, weight. and condition factor data are presented in Table 20. The Wallowa stock steelhead reared at Irrigon Hatchery were significantly longer, heavier, and had a higher condition factor than the Umatilla stock reared at Umatilla Hatchery. The percentage of Umatilla steelhead that were identified as smolts was 66%. 29%, and 66% in first, second, and third pass raceways, respectively. Descaling information is presented in Table 22. The majority of the damage was characterized at partial descaling, and was highest in the second pass raceway.

Only Umatilla stock steelhead were examined for fin erosion. All fish possessed some degree of fin erosion (Table 23). At least 97.5% of the fish were classified as having light caudal fin erosion in all raceways. Severe dorsal fin erosion was highest in the first pass raceway which contained ungraded summer steelhead.

Smolt Migration Performance: Approximately 10,000 steelhead were branded in each raceway (Table 24) and the percentage of readable brands ranged from 74% to 77%. Brand recoveries at John Day Dam ranged from 22 to 53 fish for the three raceways resulting in expanded daily passage counts of 288 to 687. Survival indexes for raceways M5A, M5B, and M5C were 8.9%. 8.4%, and 3.7%. respectively.

Steelhead from raceway M5A were released on May 12 and the first branded fish was recovered at John Day Dam on May 15, three days after release (Figure 9). Steelhead from raceways M5C and M5B were released on April 11 and 13, respectively. The first branded fish were recovered at John Day Dam 30 days after release for M5C and 24 days after release for M5B (Figure 10). Fifty-percent of the cumulative brand recoveries were reached on May 24 and 25 for all three groups despite different release dates.

Table 20. Monthly and pre-release comparisons of length, weight, and condition factor for Umatilla stock 1993 brood summer steelhead reared in Michigan raceways at Umatilla Hatchery and for Wallowa stock summer steelhead reared in Oregon raceways at Irrigon Hatchery, 1994.

Hatchery, month, raceway	Length (mm)		Weight(g)		Condition Factor	
	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
			Umatilla			
September:						
1st Pass	126	69.8(0.6)	52	4.0(0.2)	52	1.18(0.02)
October:						
1st Pass	108	93.9(1.4)	51	10.7(0.7)	51	1.15(0.01)
2nd Pass	130	92.8(1.0)	53	9.6(0.4)	53	1.11(0.01)
November:						
1st Pass	121	99.8(1.0)	48	12.2(0.0)	48	1.23(0.01)
2nd Pass	100	111.3(1.0)	50	16.9(0.7)	50	1.15(0.01)
3rd Pass	117	122.7(1.1)	66	24.0(0.9)	66	1.25(0.01)
December:						
1st Pass	109	125.1(1.6)	60	22.6(1.1)	60	1.16(0.01)
2nd Pass	107	138.4(1.2)	59	32.8(1.2)	59	1.19(0.01)
3rd Pass	110	151.5(1.6)	52	42.4(1.5)	52	1.19(0.01)
January:						
1st Pass	116	138.7(1.7)	48	32.9(1.7)	48	1.19(0.02)
2nd Pass	102	154.4(1.6)	54	46.3(1.7)	54	1.17(0.01)
3rd Pass	104	174.1(1.5)	50	61.2(2.5)	50	1.16(0.01)
February:						
1st Pass	100	160.4(2.2)	52	51.3(2.8)	52	1.16(0.01)
2nd Pass	99	181.7(2.5)	51	71.9(3.7)	51	1.50(0.39)
3rd Pass	140	194.4(1.4)	62	83.9(3.2)	62	1.10(0.03)
March:						
1st Pass	115	177.6(2.0)	53	69.3(2.4)	53	1.16(0.01)

Table 20. continued

Hatchery, month, raceway	Length (mm)		Weight(g)		Condition Factor	
	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
			Umatilla			
Pre-Release:						
1st Pass[a]	320	205.9(1.2)	103	86.7(2.5)	103	0.97(0.01)
2nd Pass[b]	312	198.3(1.2)	125	88.7(2.4)	125	1.05(0.01)
3rd Pass[b]	315	214.2(1.1)	106	93.3(2.3)	106	0.94(0.01)
			Irrigon			
Pre-Release[c]:						
1st Pass	588	221.0(1.4)	452	117.5(2.5)	452	1.05(0.01)

[a] *Steelhead from the 1st pass raceway were transferred to an acclimation pond on April 14 and released into the Umatilla River on May 12 1994.*
[b] *Steelhead from 2nd and 3rd pass raceways were transferred to acclimation ponds on March 16-17 and released into the Umatilla River on April 14+11, respectively.*
[c] *Irrigon steelhead are graded mediums and larges and are comparable to fish reared in 2nd and 3rd pass raceways at Umatilla Hatchery,*

Table 21. Mean dry feed conversion ratios for 1993 brood summer steelhead reared in Michigan raceways at Umatilla Hatchery and in Oregon raceways at Irrigon Hatchery during 1993-1994. Michigan system data also is presented by pass.

System, raceway	N	Mean food conversion ratio (SE)
Oregon[b]	1	0.90
Michigan[c]	3	1.22
1st Pass	1	1.35
2nd Pass	1	1.18
3rd Pass	1	1.12

[a] *Dry food conversion ratio is determined by pounds of fish reared/(pounds of feed * % moisture) - pounds of feed).*
[b] *Data presented for Irrigon steelhead are comparable to the data from the 1st pass raceway at Umatilla Hatchery.*
[c] *Combined lst, 2nd. and 3rd pass raceways.*

Table 22. Comparison of the proportion of descaled. partially descaled, and undamaged 1993 brood summer steelhead reared in Michigan system raceways at Umatilla Hatchery, 1993-1994.

System, raceway	N	Descaled	Partially descaled	Undamaged
Michigan:				
1st Pass	201	0.05	0.13	0.82
2nd Pass	209	0.01	0.50	0.49
3rd Pass	203	0.11	0.33	0.56

Table 23. Severity of fin erosion[a] among 1993 brood summer steelhead reared in Michigan raceways at Umatilla Hatchery in 1993-1994.

	Percent severity of fin erosion								
	Light			Moderate			Severe		
Fin	1st pass	2nd pass	3rd pass	1st pass	2nd pass	3rd pass	1st pass	2nd pass	3rd pass
Dorsal	22.9	15.8	20.2	50.2	68.4	71.4	26.9	15.8	8.4
Caudal	97.5	100.0	98.0	2.5	0.0	1.5	0.0	0.0	0.5
Pectoral	86.6	90.0	94.6	8.0	4.3	4.9	5.5	5.7	0.5

[a] *Light erosion = more than 90% of fin remaining, little or no damage.*
Moderate erosion = fin approximately 50% eroded.
Severe erosion = less than 25% of fin remaining, almost no fin rays visible.

Table 24. Brand and coded-wire-tag information for 1993 brood year summer steelhead marked at Umatilla Hatchery in 1993-1994 (POS = position of brand, LOC = location of brand, LA = left anterior, AD = adipose fin clip, CWT = coded-wire-tag.)

System, raceway	Number branded	Size	LOC	Brand	POS	Fin clip	Readable brands	CWT code	Number CWT[a]
Michigan									
1st pass	10.462	1/4"	LA	B	2	AD	7,700	070139	10,328
								070140	10.046
2nd pass	10,423	1/4"	LA	B	3	AD	7.827	070141	10,380
								070142	10.478
3rd pass	10,247	1/4"	LA	B	4	AD	7,819	070143	10,649
								070144	10,013

[a] *Number recognizably coded-wire-tagged, all CWT fish are also left ventral clipped (LV).*

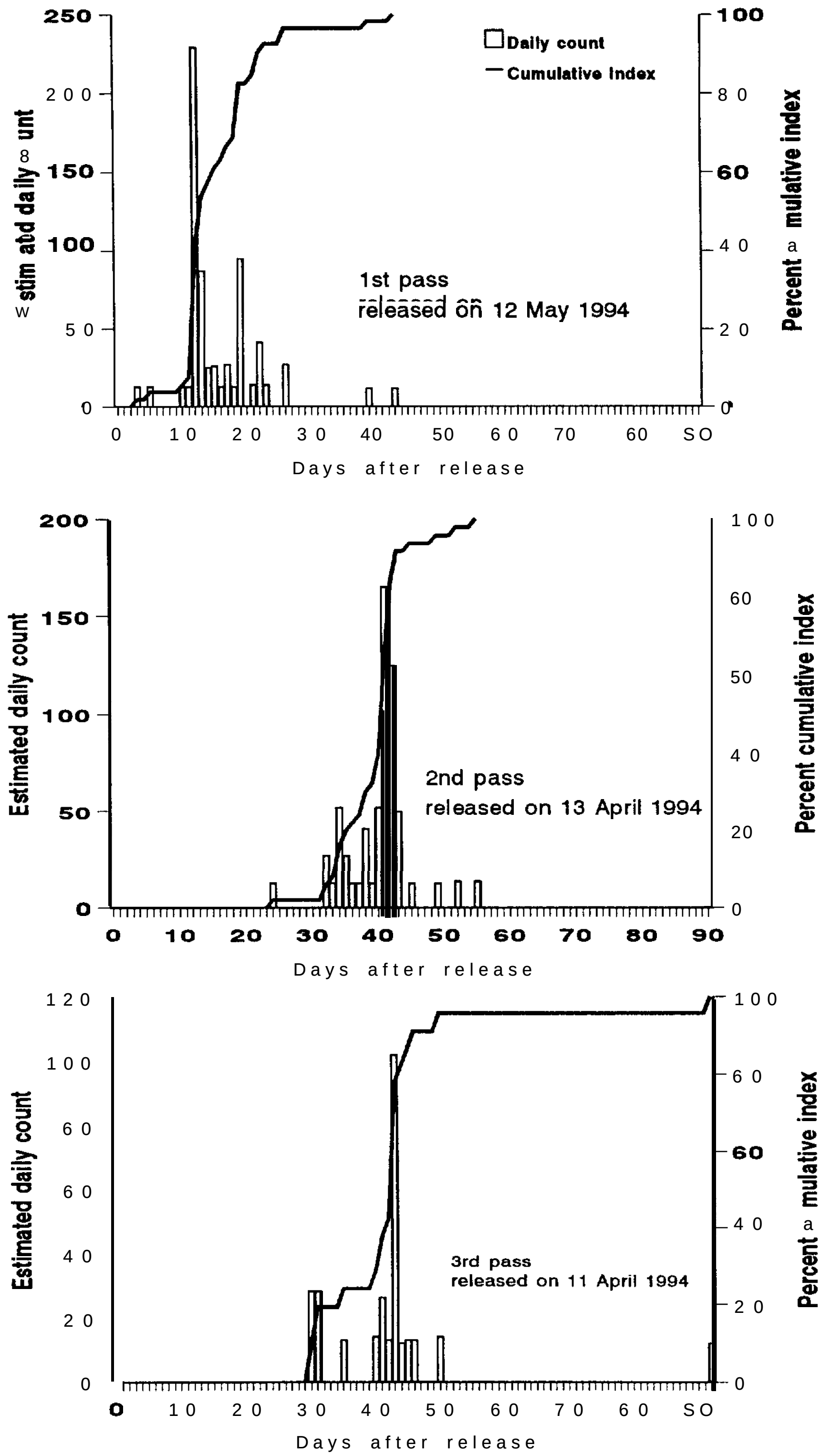
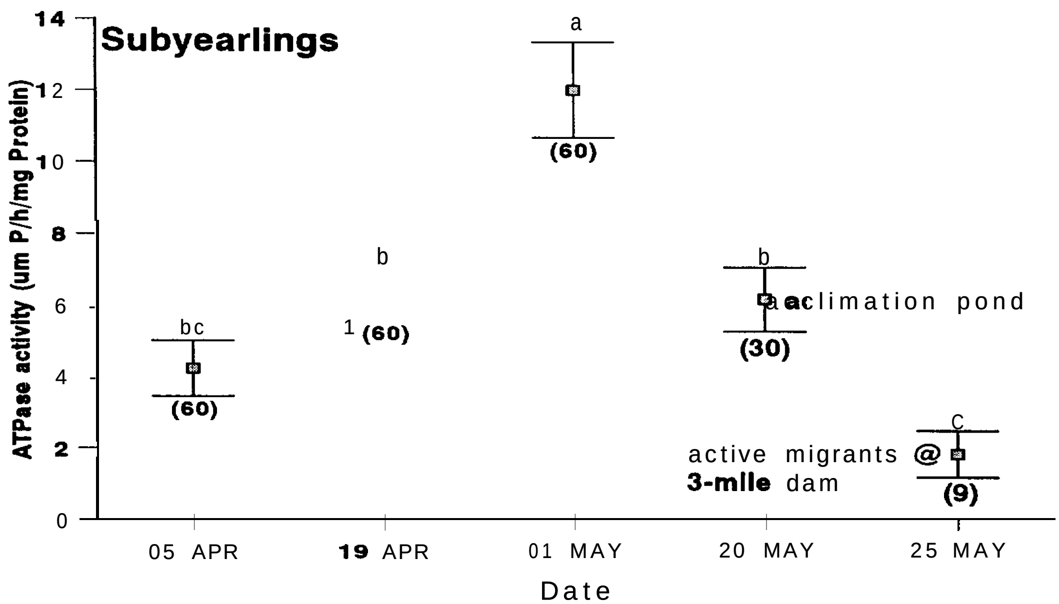


Figure 9. **Estimated dally counts and percent cumulative index of branded summer steelhead reared in Michigan raceways at Umatilla Hatchery, released in the Umatilla River on 11 April (Meacham Cr., RM 2), 13 April (Umatilla River, RM 64), or 12 May, Meacham Cr., RM 2), and recovered at the John Day Dam during 1994.**



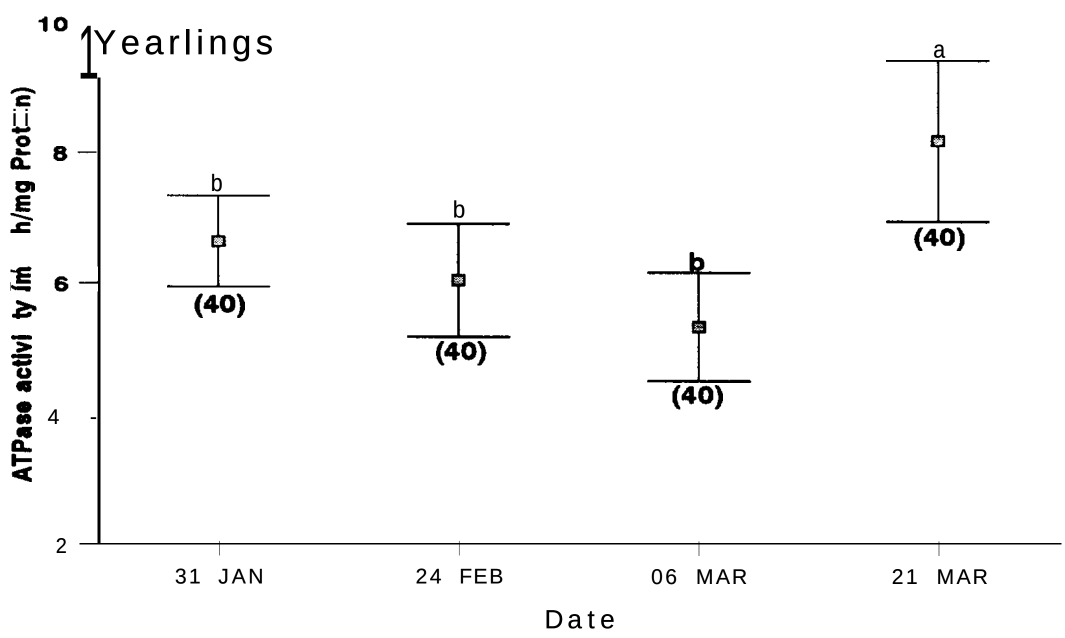


Figure 10. Gill ATPase specific activity (μm P/h/mg protein) in 1993 brood subyearling and 1992 brood yearling spring chinook salmon reared at Umatilla Hatchery and tested prior to release and at release in 1994. Bars = 95% confidence intervals. Means with similar letters are not significantly different, Sidak's multiple comparison test P>0.05.

Smolt-to-Adult Survival: The goal to mark 2 groups of 10.000 summer steelhead in each Michigan raceway was achieved (Table 24). Preliminary data showed one coded-wire-tag recovery in the Columbia gill net fishery in 1993. A 580 mm one salt steelhead was sampled and this number was expanded to six taken in the fishery. Of the 1991 brood year production at Umatilla Hatchery, eleven coded-wire-tagged fish were sampled at the Three Mile Falls Dam and Minthorn facilities in 1993-1994. This was expanded to seventeen one salt summer steelhead that returned to the Umatilla River.

Spring Chinook Salmon Yearling and Subyearling Production Evaluation

Rearing Performance

Umatilla Subyearlings: Spring chinook salmon subyearlings from the 1993 brood year were ponded into Oregon raceways in November 1993, and transferred to Michigan raceways in mid-February 1994. where they remained until they were transferred to acclimation ponds. Subyearlings reared in different Michigan passes showed similar increases in length and weight through April (Table 25). Mean food conversion ratios of subyearlings were similar for all Michigan passes (Table 26).

Umatilla Yearlings: Data on the rearing performance of 1992 brood spring chinook salmon yearlings reared in Oregon raceways at Umatilla Hatchery during 1993-1994 is presented in Table 27. The yearlings showed steady growth and the mean length, weight, and condition factors of fish reared in different passes were similar from September 1993 through February 1994. Food conversion ratios ranged from 1.65 to 1.75 and were not significantly different between Oregon passes (Table 26).

Bonneville Yearlings: The rearing performance of Bonneville yearlings was not monitored except for food conversion ratios. The ratio for yearlings raised at Bonneville Hatchery was 2.31.

Smolt Condition

Umatilla Subyearlings: There was no significant difference at pre-release in the length, weight, or condition factor of fish reared in different Michigan passes (Table 25). The proportion of subyearlings identified as smolts ranged from 0.23 to 0.60. A majority of the fish in first and second pass raceways were either partially descaled or descaled (Table 28) but fish in third pass raceways were primarily undamaged.

Spring chinook salmon subyearling ATPase levels peaked on May 1 and then declined (Figure 10). The ATPase levels at release were similar to those taken 45 and 30 days before release. Mean activity levels were lowest on May 25 when samples were collected from actively migrating fish that were recaptured at Three-Mile Falls Dam. In the ANOVA model, sampling date explained the majority of the variation and there was no significant difference between passes. Although the model indicated a significant date-by-pass interaction, the ATPase levels for all passes peaked on May 1.

Umatilla Yearlings: Pre-release data for spring chinook salmon yearlings is presented in Table 27. Yearlings averaged 56.4 g at pre-release and no significant differences were observed between fish reared in different

Table 25. Monthly and pre-release comparisons of mean length, weight, and condition factor for subyearling spring chinook salmon reared in Oregon and Michigan raceways during 1993-1994. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at P>0.05.

System, month, raceway	Length (mm) N	Length (mm) Mean(SE)	Weight(g) N	Weight(g) Mean(SE)	Condition Factor N	Condition Factor Mean(SE)
			Oregon Raceways			
December:	214	59.2(0.2)	130	2.4(0.1)	130	1.13(0.02)
1st Pass	104	9.9(0.3)	70	2.4(0.1)	70	1.13(0.03)
2nd Pass	110	58.5(0.3)	60	2.3(0.1)	60	1.14(0.01)
January:	203	69.3(0.3)	136	4.2(0.8)	136	1.23(0.01)
1st Pass	102	69.0(0.4)	84	4.2(0.1)	84	1.23(0.01)
2nd Pass	101	69.6(0.5)	52	4.4(0.1)	52	1.24(0.01)
			Michigan Raceways			
February:	329	82.2(0.3)	188	6.6(0.9)	188	1.19(0.01)
1st Pass	102	81.6(0.5)	65	6.2(0.1)	65	1.14(0.01)
2nd Pass	111	82.8(0.5)	57	7.0(0.2)	57	1.20(0.01)
3rd Pass	116	82.3(0.5)	66	6.8(0.1)	66	1.22(0.01)
March:	647	89.0(0.2)	367	9.3(0.1)	367	1.29(0.01)
1st Pass	229	89.1(0.4)	153	9.2(0.2)	153	1.29(0.01)
2nd Pass	209	89.0(0.4)	107	9.5(0.2)	107	1.30(0.01)
3rd Pass	209	88.9(0.4)	107	9.1(0.2)	107	1.27(0.01)
April:	699	106.0(0.3)	395	14.9(0.2)	395	1.21(0.01)
1st Pass	244	106.2(0.5)	118	16.0(0.3)	118	1.27(0.01)
2nd Pass	229	106.0(0.4)	156	14.5(0.2)	156	1.21(0.01)
3rd Pass	226	105.9(0.5)	121	14.3(0.3)	121	1.16(0.01)
Pre-release	950	110.3(0.2)	361	14.9(0.2)	361	1.11(0.01)
1st Pass	321	110.3(0.4)a	123	14.8(0.3)a	123	1.09(0.01)a
2nd Pass	311	110.8(0.4)a	134	15.1(0.3)a	134	1.11(0.01)a
3rd Pass	318	109.7(0.4)a	104	14.9(0.3)a	104	1.12(0.01)a

Table 26. Mean food conversion ratios for 1993 brood subyearlings spring chinook salmon and 1992 brood yearling spring chinook salmon reared at Umatilla Hatchery and released in 1994. Letters indicate statistical groupings for tests between passes based on Wilcoxon or Kruskall-Wallis test. Means with the same letters are not significantly different at P>0.05.

Release strategy, raceway	N	Mean food conversion ratio (SE)
Subyearlings	4	1.38(0.04)
1st Pass	2	1.34(0.00) a
2nd Pass	2	1.41(0.07) a
3rd Pass	2	1.30(0.11) a
Yearlings	4	1.68(0.03)
1st Pass	2	1.67(0.02) b
2nd Pass	2	1.70(0.05) b

Table 27. Monthly and pre-release comparisons of mean length, weight, and condition factor for 1992 brood yearling spring chinook salmon reared in Oregon raceways at Umatilla and Bonneville hatcheries in 1993-1994. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at P>0.05.

Hatchery, month, raceway	Lenatl (mm)		Weight(s)		Condition Factor	
	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
Umatilla Hatchery						
August:						
1st Pass	113	81.4(0.46)	61	6.0(0.15)	61	1.13(0.013)
September:						
1st Pass	214	92.4(0.31)	144	10.4(0.14)	144	1.33(0.010)
2nd Pass	229	91.3(0.32)	128	9.7(0.14)	128	1.28(0.010)
October:						
1st Pass	229	107.9(0.37)	139	16.9(0.26)	139	1.34(0.007)
2nd Pass	199	106.1(0.42)	109	16.2(0.28)	109	1.34(0.008)
November:						
1st Pass	252	118.4(0.47)	144	22.2(0.38)	144	1.33(0.007)
2nd Pass	221	118.6(0.54)	129	22.1(0.47)	221	1.30(0.009)
December:						
1st Pass	236	132.6(0.63)	136	32.9(0.59)	136	1.38(0.006)
2nd Pass	204	131.8(0.66)	123	32.5(0.65)	123	1.38(0.006)
January:						
1st Pass	212	140.0(0.84)	123	37.6(0.95)	123	1.36(0.008)
2nd Pass	215	143.1(0.86)	100	40.5(1.19)	100	1.34(0.008)
February:						
1st Pass	205	151.0(1.03)	120	43.7(1.25)	120	1.25(0.007)
2nd Pass	226	156.3(0.99)	107	49.8(1.61)	107	1.24(0.008)
Pre-Release:						
1st Pass	602	163.0(0.70)a	221	55.2(1.27)a	221	1.23(0.009)a
2nd Pass	606	163.7(0.66)a	242	57.6(1.28)a	242	1.23(0.007)a
Bonneville Hatchery						
Pre-Release:						
1st Pass	657	143.0(0.46)	220	35.0(0.67)	220	1.19(0.005)

Table 28. Comparison of the mean proportion of descaled. partially descaled, and undamaged for 1993 brood subyearling spring chinook salmon reared at Umatilla Hatchery and 1992 brood yearling spring chinook salmon reared at Umatilla and Bonneville hatcheries (SE in parentheses) during 1993-1994.

Location-strategy, system, raceway	N	Descaled	Partially descaled	Undamaged
Umatilla Subyearlings:				
Michigan	2a	**0.37** (0.07)	**0.18** (0.03)	**0.46** (0.09)
1st pass	1	0.43	0.20	0.37
2nd pass	1	0.30	0.15	0.55
3rd pass	1	0.00	0.30	0.70
Umatilla Yearlings:				
Oregon	4	**0.02** (0.01)	**0.22** (0.03)	**0.77** (0.04)
Bonneville Yearlings:				
Oregon	2	**0.05** (0.02)	**0.39** (0.08)	**0.56** (0.06)

[a] *Combined first and second pass raceways.*

Table 29. Fin clip evaluation[a] for spring chinook salmon subyearlings reared at Umatilla Hatchery and yearlings reared at Umatilla and Bonneville Hatcheries (SE in parentheses) during 1993-1994. N = number of ponds examined (~100 fish per raceway).

Rearing strategy, system	Fin Clip	N	Mean percentage of fin clip quality: Good	Fair	Poor	Unclipped
			Umatilla Hatchery			
Subyearlings						
Michigan	RV	6	**96.5** (0.9)	**1.7** (0.6)	**1.4** (0.5)	**0.5** (0.2)
Yearlings						
Oregon	LV	4	**82.8** (6.2)	**10.5 (2.9)**	**5.6** (3.0)	**1.1** (0.7)
			Bonneville Hatchery			
Yearlings						
Oregon	LV	2	**53.0** (0.2)	**18.0** (3.1)	**18.5** (2.0)	**10.6** (1.4)

a good = no fin remaining.
fair = stub to 25% remaining.
poor = 25%' to 754 of fin remaining.
unclipped = more than 75% of fin remaining.

Oregon passes for length, weight, or condition factor. Evaluations prior to release showed that 62.4% of the fish were smolts and 37.4% were intermediate smolts. A majority of yearlings showed low descaling damage (Table 28) and most received good quality fin clips (Table 29).

Specific activity levels of ATPase in spring chinook salmon yearlings were similar for the first three sampling dates but at release, activity levels increased significantly (Figure 10). Specific activity levels obtained from actively migrating fish at Three Mile Falls Dam were lower than values obtained for fish at release and measured 6.4 p-moles P/h/mg on 24 March and 4.0 p-moles P/h/mg on 29 March 1994.

Bonneville Yearlings: Yearlings produced at Bonneville Hatchery averaged 35 g at the pre-release evaluation (Table 27). A visual examination of smolt condition showed that 28.8% of Bonneville yearlings were smolts and nearly all other fish were intermediate smolts. Although a majority of yearlings showed no descaling damage, more than 40% were classified as partially descaled or descaled (Table 28). Fin clip quality was poor for fish produced at Bonneville Hatchery. We found that more than 29% of the marked fish possessed poor clips or were unclipped (Table 29).

Smolt Migration Performance

Umatilla Subyearlings: More than 10,000 spring chinook salmon subyearlings from each Michigan raceway were branded in 1994 (Table 30). Spring chinook salmon subyearlings were released from acclimation ponds on 20 May 1994 and survival indices for subyearlings recaptured at the John Day Dam ranged from 2.2% to 3.5%. Survival indices were highest for fish from second pass raceways and lowest for fish from third pass raceways (Table 31). Migrating fish were observed at John Day Dam from May 31 to July 29 and fifty percent of the brands were recovered at 22 days after release (Figure 11). We also completed test sampling for brands in the Umatilla River. We found that some fish traveled from the release site to Three Mile Falls Dam in less than five days.

Umatilla Yearlings: We branded approximately 5,000 yearlings from each Oregon raceway at Umatilla hatchery in 1994 to monitor migration success and rate to the John Day Dam (Table 30). A total of 77 branded yearlings from four raceways were recovered at the John Day Dam and 107 brands from four raceways were recovered at Bonneville Dam. These numbers were expanded to a total daily passage count of 903 at John Day Dam and 341 at Bonneville. Based on a total of 21,682 readable brands, the estimated survival index was 4.4% to John Day Dam and 1.6% to Bonneville Dam (Table 31). The survival index for yearlings from first pass raceways was significantly greater than for fish from second pass raceways.

Umatilla Hatchery spring chinook salmon yearlings were released on 21 and 22 March 1994 and some fish reached Three Mile Falls Dam by 21 March. The first and last recovery dates at John Day Dam were 9 April and 25 June. The 50% and 90% cumulative recovery period for branded fish at John Day dam was 39 days and 46 days after release. At Bonneville Dam smolts were first collected on 13 April and last observed on 17 June.

Table 30. Brand and coded-wire-tag information for 1993 brood year spring chinook salmon subyearlings and 1992 brood year spring chinook salmon yearlings reared at Umatilla Hatchery and 1993 brood year spring chinook salmon reared at Bonneville Hatchery (POS = position of brand, LOC = location of brand, RD = right dorsal, LD= left dorsal, RV = right ventral clip, LV = left ventral clip, CWT = coded-wire-tag.)

Release strategy, system, raceway	Number branded	Size	LOC	Brand	POS	Fin clip	Readable brands	CWT code	Number CWT[a]
				Umatilla Hatchery					
Subyearlings									
Michigan									
6A	10,118	3/16"	RD	5	1	RV	8,889	070734	49,726
6B	10.205	3/16"	RD	5	2	RV	9,998	070736	52,636
6C	10,206	3/16"	RD	5	4	RV	9,872	070738	51.042
7A	10,050	3/16"	LD	5	1	RV	9,217	070735	52,298
7B	10,217	3/16"	LD	5	2	RV	10,182	070737	53,172
7c	10,248	3/16"	LD	5	4	RV	9,925	070739	52.317
Yearlings									
Oregon									
4A	5,521	1/4"	RD	B	1	LV	5,419	070220	20,092
4B	5,622	1/4"	RD	B	3	LV	5.151	070219	20,971
5A	5,087	1/4"	LD	B	1	LV	5.085	070217	20.070
5B	5,303	1/4"	LD	B	3	LV	5,142	070218	19,920
				Bonneville Hatchery					
Yearlings									
Oregon									
B5	-----	---	--			LV	-----	070251	26,305
B6	-----	---	--			LV	-----	070250	26.716
B7	5,476	1/4"	LD	B	2	LV	5.200	075945	20,219
B8	5,332	1/4"	RD	B	2	LV	4.818	075944	20,109

[a] *Number recognizably tagged and released, all CWT fish are also adipose fin clipped.*

Table 31. Survival index for 1993 brood subyearling spring chinook salmon reared at Umatilla hatchery and 1992 brood yearlings reared at Umatilla and Bonneville hatcheries based on brand recoveries to the John Day Dam during spring 1994. Letters indicate statistical groupings for tests between yearling releases or between passes. Means with the same letter are not significantly different at $P>0.05$ (binomial test).

Release strategy, system, raceway	Survival index
Umatilla Hatchery	
Subyearlings	
Michigan	2.9
1st Pass	3.0b
2nd Pass	3.5a
3rd Pass	2.2c
Yearlings	
Oregon	4.4a
1st Pass	4.9r
2nd Pass	3.8s
Bonneville Hatchery	
Yearlings	
Oregon	5.4a
B7 Single Pass	5.1
B8 Single Pass	5.6

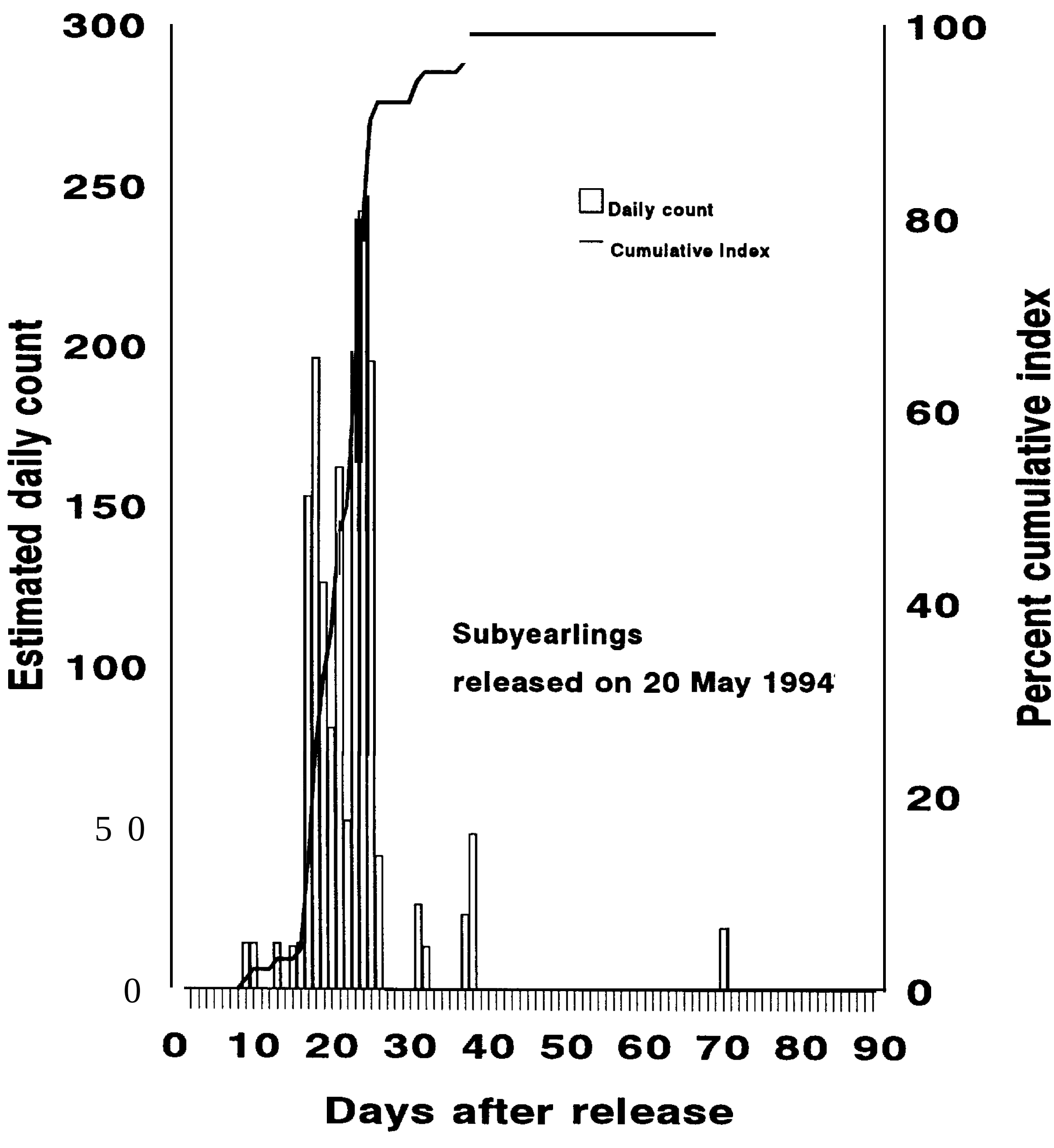


Figure 11. Estimated daily counts and percent cumulative index of branded spring chinook salmon subyearlings reared at Umatilla Hatchery, released in the Umatilla River (20 May. RM 80), and recovered at the John Day Dam during 1994.

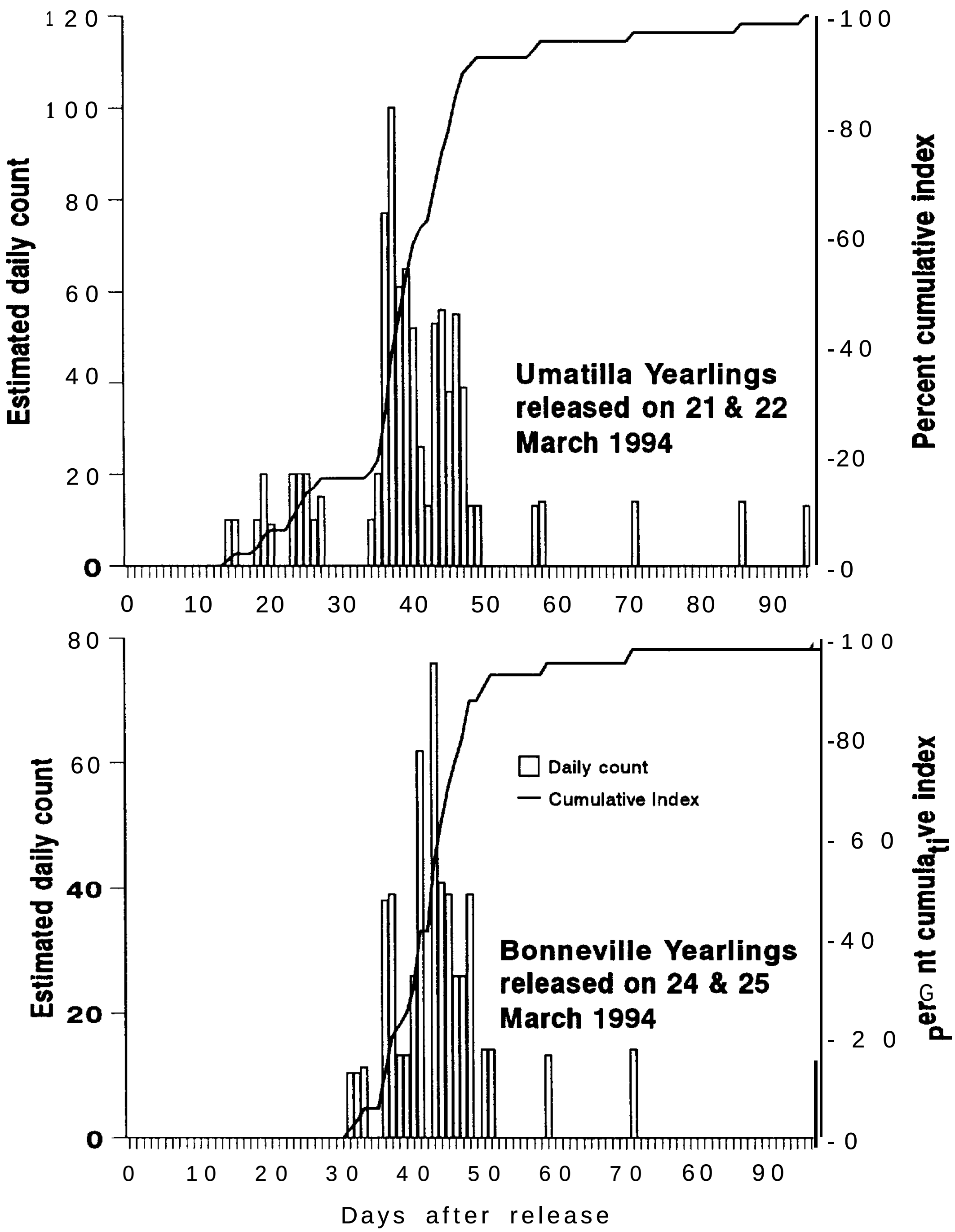


Figure 12. Estimated daily counts and percent cumulative index of branded spring chinook salmon yearlings reared in Oregon raceways at Umatilla and Bonneville Hatcheries, released in the Umatilla River (RM 80), and recovered at the John Day Dam during 1994.

Bonneville Yearlings: We monitored the migration success and rate of Bonneville Hatchery spring chinook salmon yearlings for the first time in 1994. Approximately 5,000 yearlings from two of eight raceways were branded (Table 30). The total number of readable brands released were 10,018 and the overall survival index to the John Day dam averaged 5.4%. The survival indices for spring chinook salmon yearlings reared in Bonneville Hatchery single pass raceways were similar (Table 31). There was no significant difference between survival indices for yearlings reared in first pass raceways at Umatilla Hatchery and in single pass raceways at Bonneville Hatchery (Table 31).

Yearlings were released on 24 and 25 March 1994 and some fish were recovered at Three Mile Falls Dam on 29 March 1994. The first and last recovery dates at John Day Dam were 24 April and 29 June, respectively. Fifty percent of the freeze branded fish passed the dam within 42 days after release and 90% of the brands were recovered within 50 days after release (Figure 12). At Bonneville Dam smolts were first collected on 6 May and last observed on 28 June.

Smolt-to-Adult Survival

More than 50,000 subyearlings from each Michigan raceway were Ad+CWT marked (Table 30). Tag retention for subyearlings from six raceways ranged from 97.3% to 99.3%. Two replicate groups of approximately 20,000 yearlings were coded-wire-tagged at Umatilla Hatchery (Table 30) and tag retention ranged from 96.9% to 99.7%. Approximately 20,000 yearlings were tagged in each of four raceways at Bonneville Hatchery (Table 30) and tag retention ranged from 92.5% to 94.9%.

Bonneville Hatchery Salmon Evaluation

All fall chinook salmon yearlings reared at Bonneville Hatchery and released in 1994 were coded-wire-tagged or blank-wire-tagged. Tag retention was 90.9% for coded-wire-tags and ranged from 98.6% to 99.7% for blank-wire-tagged fall chinook salmon. The percentage of fall chinook that received high quality right ventral fin clips ranged from 96.5 - 97.6%. Spring chinook salmon yearling tagging information was presented previously. The coded-wire-tag retention for spring chinook salmon yearlings ranged from 95.7% to 99.0%.

Effects of Marking on Subyearling Fall Chinook Salmon

This was the first year of subyearling fall chinook salmon returns from the marking study initiated in 1991 at Irrigon Hatchery and continued in 1992 and 1993 at Umatilla Hatchery (Keefe et al. 1993, 1994). We recovered 3 two year old fall chinook salmon with a body tag only mark, and 1 two year old fall chinook salmon with an adipose clip & coded-wire-tag & body tag mark. Future adult fall chinook salmon returns will be analyzed to determine the influence of different tag and marking techniques on survival to adulthood.

Creel Survey

Catch statistics and coded-wire-tag recovery information for 1993-94 creel surveys are reported in Tables 32 to 35. In the 1993 fall chinook salmon and coho salmon creel season on the Umatilla River from the mouth to Three Mile Falls Dam, we estimated that anglers fished 1,666 hours and caught 15 chinook salmon and 53 coho salmon, and harvested 9 and 53 respectively. We estimated that 13 summer steelhead were caught and 10 were harvested between the Highway 730 bridge and the mouth of the Umatilla River during the early season (which falls under the Columbia River regulations).

The season for summer steelhead was open from 1 December 1993 - 15 April 1994. During this period we estimated that anglers fished a total of 4,505 hours and harvested 19 of the 63 steelhead caught. We did not conduct the creel. survey between Three Mile Falls Dam and Stanfield Dam because there was not a significant amount of pressure observed during the 1993 season. However, spot checks did indicate occasional angling activity in this area.

The Umatilla River was not opened in 1994 for spring chinook salmon because of the low number of adults that returned to Three Mile Falls Dam. The majority of anglers that fished the Umatilla River were residents of Umatilla and Morrow counties.

Planning and Coordination

The research monitoring and evaluation team has participated in planning and coordination activities for the Umatilla Basin. We have assisted the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in determining sacrifice rates of coded-wire-tagged fish for research needs and in determining data and methods needed to make adult predictions. We have participated extensively in hatchery production planning. We provided personnel to work cooperatively with hatchery personnel and CTUIR teams to collect data from returning adults at Three Mile Falls Dam. We have cooperated with several groups in forming the Umatilla Monitoring and Oversight Committee. This group has been established to ensure that long-term research goals are being achieved and that there is minimal duplication of effort. Project personnel also participated in the section 7 consultation process with National Marine Fisheries Service and Bonneville Power Administration personnel.

Table 32. Estimated catch statistics for fall chinook salmon and coho salmon in the lower Umatilla River from the confluence with the Columbia River to Three Mile Falls Dam for the' 1993 fall chinook/coho salmon creel season[a]. Number caught and number harvested includes ± 95% confidence interval.

				Fall Chinook Salmon			Coho Salmon		
Month, day type	# Sampled days	anglers	Hrs fished	Number caught	Number harvested	Catch rate (fish/h)	Number caught	Number harvested	Catch rate (fish/h)
October									
Weekday	9	117	298	5± 7	0	0.007	14±12	14±12	0.020
Weekend	10	263	734	3± 1	3± 0	0.004	32±14	32±14	0.044
Total	19	380	1032	8± 8	3± 0	0.005	46±18	46±18	0.036
November									
Weekday	7	56	136	6± 6	6± 0	0.015	6± 7	6± 7	0.016
Weekend	10	203	498	1± 0	0	0.002	1± 0	1± 0	0.002
Total	17	259	634	7± 6	6± 0	0.005	7± 7	7± 7	0.005
Grand Total	36	639	1666	15± 9	9± 9	0.005	53±19	53±19	0.024

[a] *Steelhead could be harvested below the Highway 730 bridge and were included in the survey. We estimated that 13±4 steelhead were caught and 10±2 were harvested in this section of the Umatilla.*

Table 33. Estimated catch statistics for 1993-94 summer steelhead creel. Lower river = Mouth of the Umatilla River to Three Mile Falls Dam. Upper River = Stanfield Dam to the Confedera ted Tribes of the Umatilla Indian Reservation lower boundary. Number caught and number harvested includes ± 95% confidence interval.

Month, day type	Number sampled days	Number sampled anglers	Hours fished	Number caught	Number harvested	Catch rate (fish/h)
			Lower River			
December						
Weekday	4	59	941	8±15	8±15	0.009
Weekend	4	82	599	6± 9	2± 4	0.836
Total	8	141	1540	14±18	10± 4	1.350
January						
Weekday	3	15	137	0	0	0.000
Weekend	6	79	300	20±11	4± 5	0.068
Total	9	94	437	20±11	4± 5	0.057
February						
Weekday	3	2	46	0	0	0.000
Weekend	5	32	118	0	0	0.000
Total	8	34	163	0	0	0.000
March						
Weekday	5	28	162	0	0	0.000
Weekend	4	33	65	0	0	0.000
Total	9	61	227	0	0	0.000
April						
Weekday	2	16	191	0	0	0.000
Weekend	2	28	108	0	0	0.000
Total	4	44	299	0	0	0.000
Grand Total	38	374	2666	34±21	14±17	0.018

Table 33 continued.

Month, day type	Number sampled days	anglers	Hours fished	Number caught	Number harvested	Catch rate (fish/h)
			Upper River			
December						
Weekday	5	17	207	0	0	0.000
Weekend	3	24	187	3± 5	0	0.016
Total	8	41	394	3± 5	0	0.008
January						
Weekday	4	0	15	0	0	0.000
Weekend	4	37	269	10±10	0	0.037
Total	8	37	284	10±10	0	0.035
February						
Weekday	4	21	334	16±17	5± 9	0.048
Weekend	4	42	251	0	0	0.000
Total	8	63	585	16±17	5± 9	0.027
March						
Weekday	4	6	125	0	0	0.000
Weekend	5	36	179	0	0	0.000
Total	9	42	304	0	0	0.000
April						
Weekday	2	13	246	0	0	0.000
Weekend	2	7	25	0	0	0.000
Total	4	20	271	0	0	0.000
Grand Total	37	203	1838	29±21	5± 9	0.019

Table 34. Residence of anglers for the 1993 fall chinook and coho salmon creel survey, and the 1993-94 summer steelhead creel survey in the Umatilla River.

River, section	Fishery	Anglers interviewed	Angler residence (%)		
			Umatilla and Morrow Counties	Other Oregon counties	out of state
Umatilla	fall chinook and coho salmon	640	94.2	4.1	1.7
Lower Umatilla	summer steelhead	374	92.3	4.8	2.9
Upper Umatilla	summer steelhead	203	92.1	7.4	0.5

Table 35. Coded-wire-tagged recoveries for the 1993 fall chinook salmon and coho salmon creel survey, and the 1993-94 summer steelhead creel survey in the Umatilla River.

Fishery	Tag Code	Number Observed	
		Observed	Expanded
Coho Salmon	075621	1	1
Summer steelhead	075340	2	2
	075341	2	2
	075343	1	1
	075344	1	1
	075345	2	2

DISCUSSION

Fish Cultural Practices

Annual production goals at Umatilla Hatchery have been achieved for most release groups because of better than expected egg-to-smolt survival rates and the use of oxygen supplemented Michigan raceways. Fall chinook salmon subyearling egg-to-smolt survival rates exceeded 81% in 1994, well above the predicted rate of 64%. All other groups also exceeded the predicted survival rates. Despite chronic water shortage problems, significant production levels have been maintained by rearing fish in high density Michigan raceways.

Size at release goals have not been consistently reached for all groups. Fall chinook salmon subyearlings released in 1994 were 65 fish/lb, compared with a target size of 60 fish/lb and were slightly smaller than fish released in 1993. Poorer growth may have been caused by additional handling during blank-wire-tagging. Spring chinook salmon released in the fall at 20 fish/lb were below the release goal of 12 fish/lb and may result in reduced survival. Subyearlings from Umatilla Hatchery were released at 30 fish/lb, well below the goal of 20 fish/lb. The size-at-release of subyearlings has never been close to the goal of 15 fish/lb recommended in the master plan (CTUIR and ODFW 1990). Failure to reach size-at-release goals for this group may result in poor smolt-to-adult survival.

Water Quality Monitoring

Measurements of water quality parameters at the Umatilla Hatchery continued to show few differences between systems. Most differences that have occurred have been small and are probably not biologically significant. We found that oxygen levels dropped slightly below the minimum recommended level of 6.5 ppm, but this occurred rarely. Maximum levels of dissolved oxygen in the oxygen supplemented Michigan raceways were below levels that cause damage to fish because of chronic exposure (Colt et al. 1991). Unionized ammonia levels only approached the critical level of 12.5 ppm on one occasion in a Michigan summer steelhead raceway. High loading levels in Michigan raceways could cause total gas pressure to increase Colt et al. 1991). This results from an increase in carbon dioxide levels and can have detrimental effects on fish. However we observed no statistical differences in total pressure at the head or tail of raceways between systems or between passes in the Michigan system. We did not monitor water quality at the Irrigon or Bonneville hatcheries: therefore, we could not make comparisons between the hatcheries.

Rearing Performance and Survival Studies

System Evaluations

Data from 1993-1994 rearing performance and smolt condition studies indicates that smolts produced in Michigan raceways are similar to smolts produced in Oregon raceways. Tests of fall chinook salmon subyearlings and spring chinook salmon released in the fall show that fish from each system respond to stress in a like manner and similarly migrate to the John Day dam (subyearlings). Although fish reared in Oregon raceways were significantly larger at pre-release in 1993-1994. this has not been a consistent trend (Keefe et al. 1993, 1994). Information from 1993-1994 also showed significantly poorer food conversion ratios and greater descaling for fish reared in Michigan raceways. Poorer food conversion ratios for Michigan reared fish were also reported in 1993, but greater descaling has not always occurred (Keefe et al. 1993. 1994). This was the first year in which all fall chinook salmon raceways were treated equally. In past years fish in Oregon raceways were subjected to additional handling stress because of blank-wire-tagging. We continue to believe that many of the year to year differences observed reflect random variability. Adult return data from past and future releases will help to clarify differences between systems, if they exist.

Within System Evaluation

Overall, few differences were found in rearing and performance parameters for fish reared within the Michigan or Oregon raceways. In contrast to previously collected data (Keefe et al. 1993, 1994) we observed few differences among passes with respect to fish size, condition, or survival to the John Day Dam. In some cases fish from third pass raceways performed more poorly than fish from first and second pass Michigan raceways; however, these differences were not consistent. In general, no trends for poorer or better rearing conditions between passes of Michigan or Oregon raceways has been apparent to date. Adult return data collected in the future will help us to determine if any differences observed among passes were biologically significant.

Spring Chinook Salmon Yearling and Subyearling Production Evaluation

The finding that the outmigration performance of yearling spring chinook salmon reared at Bonneville and Umatilla Hatcheries was similar is important because yearling releases from Bonneville Hatchery are intended to be used as a basis to compare the survival of yearling and subyearling smolts. Although subyearlings migrated more quickly than yearlings, they had a lower survival index. Also, subyearling and yearling migration was not directly comparable because yearlings were released at a much earlier date. The fact that some yearlings and subyearlings moved quickly past Three Mile Falls Dam immediately after release, suggests that much of the travel time to the John Day Dam is spent in the lower Umatilla River or in the Columbia River. Yearling and subyearling spring chinook salmon have been reared at Umatilla Hatchery because we do not know the optimum size and time for release of spring chinook salmon juveniles in the Umatilla River. In addition, yearlings produced at Umatilla Hatchery undergo an extensive period of egg chilling compared with similar sized Bonneville yearlings. We do not know if Umatilla yearlings will perform as well as Bonneville yearlings.

Peak gill ATPase levels in subyearlings occurred 3-weeks prior to release and low ATPase levels were found in actively migrating yearlings and subyearlings. If gill ATPase activity is an accurate indicator of smoltification and migratory readiness, then subyearlings may have been released too late in the season. However, many subyearlings rapidly moved past Three-Mile Falls Dam and studies on the Rogue River (Ewing et al. 1980) have indicated that elevated gill ATPase activity is not a prerequisite to migratory movement. Subyearlings might be released earlier in the season to coincide with higher ATPase levels, but size at release goals for this group have never been reached. Subyearling releases have ranged from 20-30 fish/lb compared with a release goal of 15 fish/lb.

Effects of Marking on Subyearling Fall Chinook Salmon

The evaluation of marking on subyearling fall chinook salmon was implemented to assess the potential of body tags and ventral fin clips as a mass mark for production purposes. Adult return and smolt-to-adult survival data is still unavailable to assess the impacts of various marks on survival. However, 1993 was the first year of potential adult fall chinook salmon returns for the mark evaluation study. The large size of fall chinook salmon made detection of body tags difficult because the fish were not easily passed through the magnetic field detector and this caused the detector to beep when a tag may not have been present. We are currently designing a new method to detect body tags in adult fall chinook salmon. Future returns from the current marking program will provide information on the smolt to adult survival of differentially marked fall chinook salmon.

Creel Survey

The number of fall chinook jack salmon and coho salmon passing Three Mile Falls Dam in 1993 were 27 and 1,113. respectively and the estimated number harvested below the dam were 3 and 56 fish, respectively. This harvest represents 10% of the fall chinook jack salmon run and 5% of the coho salmon run to Three Mile Falls Dam. As an overall contribution to the sport fishery on the Umatilla River, the fall chinook jack salmon and coho salmon fishery provided 833 hours of effort per month. In comparison. the summer steelhead fishery provided 984 hours of effort per month. Angling pressure for both fisheries was approximately 25% less than the preceding year.

During the 1993-94 summer steelhead fishery, five of the scheduled creel days were not sampled because of flooding and were considered to be zero effort and zero catch. Summer steelhead counts passing Three Mile Falls Dam were low (1.290 fish) compared to the average for previous years (2,083 fish). The majority of the run passed before the season closed on 15 April 1994 and 73% of the run consisted of wild steelhead. The summer steelhead punch card estimate for December 1993 was 44 fish. This is lower than the 27 year average of 90 fish. In comparison. the estimated summer steelhead catch from creel survey data was 10±4 for the month of December. Data from the 1994 punch card estimates for the steelhead fishery are not yet available. Anglers caught more than twice the number of fish for each hour of effort in 1992-93 (0.05 fish/h) than in 1993-94 (0.018 fish/h). The 1993-94 catch rate on the upper Umatilla River was similar to the lower river fishery at 0.019 fish/h. This is higher than the catch rate for the 1992-93 upper river fishery (0.006 fish/h). The catch rate on the lower Umatilla River for summer steelhead (0.05 fish/h) was similar in comparison to other summer steelhead fisheries in northeast Oregon. For example, anglers on the lower Grande Ronde River and the lower Wallowa River caught summer steelhead at a rate of 0.057 fish/h and 0.082 fish/h, respectively (Flesher et al. 1993).

There was no spring chinook salmon fishery in 1994. The spring chinook salmon runs at Three Mile Falls Dam for the years 1989-1993 ranged from 163-2,190. The 1994 counts were at the lower end of the range at 266 fish.

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LITERATURE CITED

Bonneville Power Administration. 1987. Environmental assessment of Umatilla Hatchery. Office of Power and Resources Management, Portland, Oregon.

Carmichael, R. W. 1990. Comprehensive plan for monitoring and evaluation of Umatilla Hatchery. Pages 60-90 in Umatilla Hatchery Master Plan. The Confederated Tribes of the Umatilla Indian Reservation and Oregon Department of Fish and Wildlife. Submitted to the Northwest Power Planning Council. Portland, Oregon.

Colt, J., K. Orwicz. and G. Bouck. 1991. Water quality considerations and criteria for high-density fish culture with supplemental oxygen. Pages 372-385 in J. Colt and R. J. White, editors. Fisheries Bioengineering Symposium. American Fisheries Society, Bethesda, Maryland.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1990. The Umatilla Hatchery Master Plan Submitted to the Northwest Power Planning Council, Portland, Oregon.

Ewing. R.D.. C.A. Fustish, S.L. Johnson, and H.J. Pribble. 1980. Seaward migration of juvenile chinook salmon without elevated (Na+K)-ATPase activities. Transactions of the American Fisheries Society, 109:349-356.

Flesher. M.W. 1993. Summer steelhead creel surveys on the Grande Ronde. Wallowa, and Imnaha Rivers for the 1990-91 run year. Progress report, Oregon Department of Fish and Wildlife.

Keefe. M.L., R.W. Carmichael, R.A. French, W.J. Groberg, and M.C. Hayes. 1993. Umatilla hatchery monitoring and evaluation. Annual progress report to Bonneville Power Administration, Portland. Oregon.

Keefe. M.L., R.W. Carmichael, S.M. Focher, W.J. Groberg, and M.C. Hayes. 1994 Umatilla hatchery monitoring and evaluation. Annual progress report to Bonneville Power Administration, Portland, Oregon.

Nielsen, L.A., D.L. Johnson, and S.L. Lampton. 1983. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry. W.H. Freeman and Company, New York.

Standard Methods for the Examination of Water and Waste Water. 1980. 15th Edition.

REPORT B

Fish Health Monitoring and Evaluation

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FISH HEALTH MONITORING AND EVALUATION

INTRODUCTION

Fish health operations proceeded as scheduled during the third year of monitoring and evaluation. Fall chinook salmon adults were sampled at Priest Rapids and Minthorn since fertilized eggs from fish at these sites were substituted for those from Bonneville for Umatilla Hatchery production.

For the first time in three years of production, bacterial kidney disease (BKD) was the most significant infectious disease at Umatilla. Increased losses of Carson spring chinook salmon juveniles to BKD were very evident and documented. An unscheduled erythromycin feeding was required to control the infection in the yearlings. This episode of BKD provided opportunities to investigate certain aspects of the epidemiology of *Renibacterium salmoninarum* (Rs) infection among fish at Umatilla Hatchery.

METHODS

Methods as described in the two previous annual reports (Keefe et al. 1993 and 1994) were used. In those reports the dilutions used on kidney samples for the enzyme-linked immunosorbent assay (ELISA) were described as 1:4, 1:8, 1:16 or 1:32 weight of kidney tissue per volume of diluent. To be consistent with other laboratories using ELISA. these same dilutions will now be defined as 1:3, 1:7, 1:15 or 1:31 weight of kidney to volume of diluent. respectively.

Juvenile Monthl y Monitoring

Statistical analyses comparing the percentage of fish with clinical levels of Rs infection (21.000 OD {optical density at 405 nanometers} units) were made using a two-tailed t-test ($\alpha = 0.05$). These comparisons were made between Oregon and Michigan raceways of the 92 brood year Carson spring chinook salmon released in the fall and between the 04 and 05 Oregon series of raceways of the 92 brood year Carson spring chinook salmon reared as yearlings.

Juvenile Preliberation Monitoring

There was only sufficient sample volume in 185 of the 300 Priest Rapids-Umatilla fall chinook salmon juveniles to have replicate wells for ELISA. The data on the other 115 is based on a single sample well. Investigations reported in the last annual report where the direct fluorescent antibody stain (DFAT) and ELISA were compared. suggest that ELISA data from a single sample is far more informative than data from the DFAT. which would be the alternative for small fish such as the fall chinook salmon. The cumulative data from three years using ELISA also indicates that with good quality control. there is little variation between sample replicates.

For statistical analyses of all ELISA data the OD_{405} values were log-transformed (Ott 19771. One-way analysis of variance (ANOVA) was used to compare 30-fish samples among Oregon raceways and 30-fish samples among Michigan raceways in the

92 brood year Carson spring chinook salmon juveniles released in the fall. Two replicate 30-fish sample groups per raceway were used for these comparisons. The first replicate was used for one ANOVA and the second replicate was used for a second ANOVA on the same raceways. ANOVA and these same sets of sample groups were also used to compare upper Oregon with upper Michigan raceways, and lower Oregon with middle Michigan raceways.

Because of the BKD in the 92 brood year Carson spring chinook salmon juveniles scheduled for fall release, the two 30-fish grab-sampled groups per raceway were used for an additional statistical comparison. This was a comparison between the two 30-fish sample groups (replicates) within a raceway. These analyses were considered important to establish the reliability of using 30-fish samples as defined in the project work statement. Because of the time required for removing and processing kidneys for the ELISA, fish in sample groups designated 31-60 (the second 30-fish sample group) for each fall release raceway were not bled and their carcasses were frozen prior to removing the kidney sample for ELISA. Those fish in sample groups designated 1-30 were bled for erythrocytic inclusion body syndrome (EIBS) assays when they were sacrificed at the hatchery and their kidneys were removed from the fresh carcasses. The statistical test used for these analyses was a two-tailed t-test (α = 0.05).

Statistical comparisons of log-transformed ELISA data were also made between comparable raceways of the 92 brood year Carson spring chinook salmon juveniles released in the fall and those released as yearlings. The 120 fish from the fall release group were in the 02 and 03 Oregon series and those released as yearlings were in the 04 and 05 series. Means of log-transformed ELISA values of the 120 fish from these raceways were compared by a two tailed t-test (α = 0.05).

Juvenile Disease Outbreak Monitoring

Data concerning an episode of BKD which began during the period of the last year's annual report are given in this report. The outbreak occurred in the 92 brood year Carson spring chinook salmon scheduled for fall release. which were liberated in November of 1993. Preliberation ELISA data were collected at that time and therefore an epidemiological synthesis of this is appropriate for this annual report.

A two-tailed t-test (α = 0.05) was used to compare cumulative percent mortality between Oregon and Michigan raceways of the 92 brood year Carson spring chinook salmon reared for fall release. A Chi-square analysis was used to compare percent mortality between upper and lower Oregon raceways, and among upper, middle and lower Michigan raceways of 93 brood year Carson spring chinook salmon also reared for fall release.

Broodstock Monitoring

Adult fall chinook salmon for the 93 brood year program at Umatilla were sampled at Priest Rapids and Minthorn. The adults at Minthorn were trapped at the Three Mile Falls Dam Trap on the lower Umatilla and held at Minthorn Ponds for spawning. Eggs from both stocks were consolidated at Umatilla and given the Priest Rapids lot number of 45. Sampling of fall chinook salmon adults at Bonneville continued under protocols of the Umatilla Hatchery Fish Health Monitoring and Evaluation project.

Investigational New Animal Drug Monitoring

An unscheduled erythromycin treatment was required for the 92 brood year Carson spring chinook salmon juveniles programmed for release as yearlings in April of 1994. Losses attributed to BKD increased significantly in November of 1993, and a 21-day erythromycin therapeutic regimen at a dosage of 92 mg per kg body weight per day was authorized via an amended Investigational New Animal Drug (INAD) application submitted to Christine M. Moffitt of the University of Idaho. A scheduled erythromycin treatment under an INAD was advanced from October to September of 1993 for the 93 brood year Carson spring chinook salmon, scheduled for fall release, because of increased losses to BKD during September. Standardized INAD toxicity tests were done on the yearlings following the amended feeding in November 1993 and after their third and final feeding in February 1994. Similar toxicity test's were done on the fish scheduled for fall release after their first feeding in April 1994 and following completion of their final feeding in October 1994.

As with 92 brood year subyearlings, the 93 brood year Carson spring chinook salmon received two different erythromycin treatments while they were divided between two Oregon raceways. Those in 01A received a 21 day treatment and those in 01B received the antibiotic for 35 days. Toxicity tests were conducted after their respective treatment regimens. The INAD submitted for these fish included a second feeding prior to their release in April 1994. Due to late operational changes calling for transfer of these fish to acclimation ponds, the feeding and mandatory toxicity tests could not be done before they were transferred; thus, the second feeding was canceled.

RESULTS

Juvenile Monthly Monitoring

Necropsies

External parasites were not detected in wet mounts of gill or body scrapings from a total of 408 moribund/fresh-dead fish and 300 grab-sampled healthy fish examined by microscopy. Gill condition of healthy fish was normal by gross examination--occasional minor gill aneurysms were observed--and none of the moribund/fresh-dead fish showed evidence of bacterial gill disease. Yellow pigmented gill bacteria were isolated from 30.0% (6/20) of the moribund/fresh-dead steelhead (Appendix Table A-7). *Flexibacter psychrophilus* specific antiserum was used to test one of these isolates in the rapid slide agglutination test and it was positive for the cold water disease (CWD) bacterium. Similar bacteria were isolated from 30.8% (12/39) of the moribund/fresh-dead fall chinook salmon juveniles and 16.7% of 12 isolates tested with *F. psychrophilus* antiserum were positive (Appendix Table A-8). This bacterium was detected systemically in 13.2% (7/53) of these same steelhead (Appendix Table A-7) and in 5.1% (2/39) of the same fall chinook salmon examined (Appendix Table A-8). Yellow pigmented bacteria were isolated from the gills of 33.3% (12/36) of the 93 brood spring chinook salmon juveniles scheduled for subyearling release (Appendix Table A-9). from 4.2% (4/95) of the 93 brood year spring chinook salmon juveniles scheduled for fall release (Appendix Table A-10). from 23.7% (27/114) of the 92 brood year spring chinook salmon scheduled for fall release (Appendix Table A-11). and from 27.5% (14/51) of the 92 brood year spring chinook salmon scheduled for release as yearlings (Appendix Table A-12). The CWD bacterium was detected systemically in only 0.9% (4/438) of the moribund/fresh-dead spring chinook salmon examined from these populations (Appendix Table A-9-12). Possible (EIBS) inclusions were observed in 2.4% (4/166) moribund chinook salmon examined and in none of 207 grab-sampled healthy chinook salmon. In the possible EIBS positive fish the number of inclusions ranged from 2 to 8 per fish and in each case the fish had associated fungal or bacterial infections.

Assays for *Renibacterium salmoninarum* by the ELISA and DFAT

Forty-three moribund/fresh-dead and 30 grab-sampled normal appearing Umatilla summer steelhead (91.93) were tested by the ELISA for Rs during the six months of monthly monitoring (Appendix Table A-13). Kidney tissue from these was homogenized at a 1:7 or 1:15 dilution (reported as 1:8 or 1:16 in the two previous annual reports). The mean OD reading for the moribund/fresh-dead steelhead was 0.065 and the range was 0.006-0.514. Three fish had OD values in the very low level positive range (0.104, 0.143 and 0.193) while two had moderate Rs positive values (0.448 and 0.514). The mean for the 30-grab sampled steelhead was 0.053 and the range was 0.006-0.593. Two of these 30 had definite positive OD values of 0.152 and 0.593.

Thirty-nine moribund/fresh-dead and 20 grab-sampled 93 brood year fall chinook salmon from four Oregon raceways were examined in February and March for Rs by the DFAT (Appendix Table A-14): all 59 were negative.

Ten moribund/fresh-dead and 20 grab-sampled 93 brood year Carson spring chinook salmon, released as subyearlings. from two Oregon raceways (O1A-B) were examined in December 1993 and January 1994 for Rs by the DFAT (Appendix Table A-15). Only 1/25 (4.0%) of these was rated as 1+ positive; the others were negative. Forty-one moribund/fresh-dead of this stock from nine Michigan raceways (M6A-C, M7A-C and M8A-C) were examined by the ELISA during monthly monitoring in February and March of 1994 (Appendix Table A-15). Of these, only 8.0% (2/25) were Rs positive at very low levels (0.113 and 0.115 OD units). Fifteen fish from the lower raceways of these three Michigan series were also grab-sampled for the ELISA. Three of these were Rs positive (20.0%) in the OD range of 0.100-0.199; one was positive at a near-clinical level of infection (0.987).

In March and April of 1994 a total of eight moribund/fresh-dead and 10 grab-sampled 93 brood year Carson spring chinook salmon, scheduled for fall release, were assayed for Rs by the DFAT: all 18 were negative (Appendix Table A-16). From May through July, 45 moribund/fresh-dead and 20 grab-sampled fish were assayed for Rs by the ELISA. Of these, only two dead fish had OD readings greater than 0.100 (0.128 and 0.330). During monthly monitoring in August, however, swollen kidneys or pustules in the kidneys characteristic of BKD were noted in 90% (9/10) of the moribund/fresh-dead fish from lower Michigan raceways (M2C and M3C). The ELISA's of these confirmed the apparent onset of BKD in the lower Michigan raceways. These same nine fish had OD values well above the clinical cutoff of 1.000; one had a very low value of 0.044 (Appendix Table A-16). Also, one of ten grab-sampled fish from a lower Michigan raceway (M3C) had a clinical value of 2.583: nine were less than 0.100 OD units. Gross examination of 32 moribund/fresh-dead fish from the other Michigan and Oregon raceways indicated that only two had swollen kidneys: no kidney pustules were observed. The ELISA of these were also consistent with the gross observations. The two fish with swollen kidneys had ELISA OD's in the clinical range (0.996 and 2.663). one had an OD of 0.106. and the other 29 had OD values less than 0.100. All ten grab-sampled fish from the two lower Oregon raceways had OD's less than 0.100. Monthly monitoring during late September continued to verify that the ongoing BKD was predominantly in the lower Michigan raceways. Seven of ten (70%) moribund/fresh-dead fish from M2C and M3C had greater-than clinical levels of Rs antigen: three had OD's less than 0.100 (Appendix Table A-16). One grab-sampled fish from these lower Michigan raceways had an OD of 0.306: the other nine were less than 0.100. In the other Michigan and Oregon raceways during September. four had OD's in the moderate range (0.306, 0.351, 0.535 and 0.696). six were in the low OD range (0.105, 0.113, 0.151, 0.215, 0.244 and 0.279). and the remaining 26 were less than 0.100. Two grab-sampled fish from lower Oregon raceways were in the low range (0.134 and 0.248); the other eight were less than 0.100.

Five moribund/fresh-dead and five grab-sampled 92 brood year spring chinook salmon scheduled for fall release were examined by the DFAT for Rs while they were in one Oregon raceway (O1A) during May of 1993 (Appendix Table A-17). One of the five moribund/fresh-dead was rated a 1+ positive. In June, by ELISA. 20.0% (2/10) of the moribund/fresh-dead had clinical levels of Rs (examined by DFAT): in July 41.2% (7/17) were clinically positive: in September 77.8% (35/45) were at this level: and during October 52.0% (26/50) were clinically infected (Appendix Table A-17). Also, during these same four months, 23.6% (13/55) of the grab-sampled fish had moderate levels of Rs antigen (0.400-0.599 OD units); 7.3% (4/55) had high levels (0.600-0.799 OD units); 1.8% (1/55) had very high levels (0.800-0.999 OD units): and 7.3% (4/55) showed clinical levels of infection. During September and October of 1993 the fish were distributed among four Oregon raceways (O2A-B and O3A-B) and six Michigan raceways (M2A-C and M3A-C). The portion of moribund/fresh-dead fish with clinical Rs antigen levels during these months was 57.5% (23/40) in Oregon raceways and 69.1% (38/55) in Michigan raceways. The difference between the Oregon and Michigan raceways was determined to be statistically significant ($p \leq 0.041$).

During monthly monitoring 206 moribund/fresh-dead spring chinook salmon of the 92 brood year, programmed as yearlings, from four Oregon raceways (O4A-B and O5A-B) and two Michigan raceways (M5A and M5B) were examined from August 1993 through February 1994 (Appendix Tables A-18 and A-19). The prevalence (Figure 1) and proportion of these fish with clinical levels of Rs antigen by month was as follows: April 0% (0/5-examined by DFAT), May 0% (8/15-5 examined by DFAT and 5 examined by ELISA), October 95% (19/20), November 40% (8/20), December 55% (11/20), January 45% (9/20) and February 45% (9/20). In grab-sampled fish during this period 1.4% (1/70) had clinical levels and 21.4% (15/70) had OD values between 0.400 and 1.000. The prevalence and proportion of the moribund/fresh-dead fish with clinical levels antigen, by raceway, is shown in Table 1. Among four Oregon raceways, during the three months from September 15 to December 15, the average daily mortality was significantly less for 04A (10.9 fish/day), than for 04B (27.8 fish/day), for 05A (30.0 fish/day) and for O5B (25.1 fish/day) ($p \leq .0000015$). Using this same statistical parameter, average daily mortality for the four Oregon raceways combined and the two Michigan raceways combined, the Michigan raceways were significantly less.

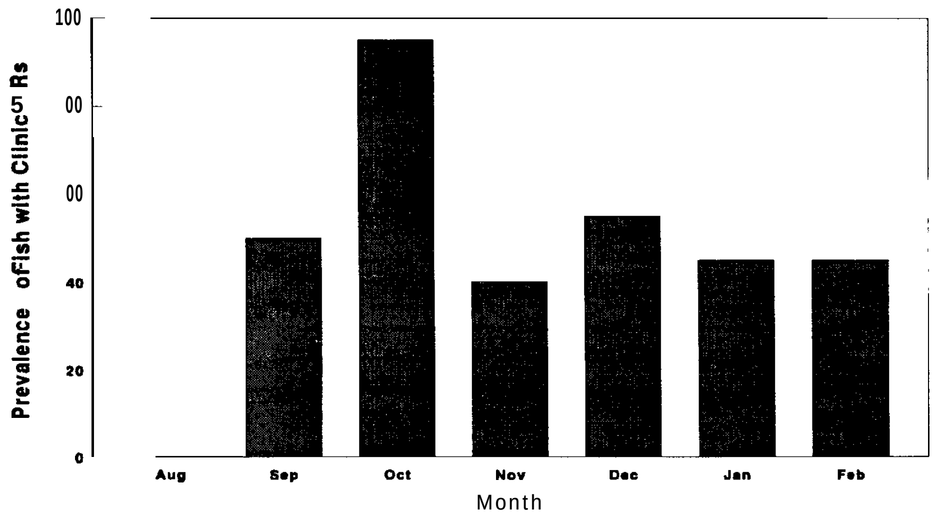


Figure 1. Prevalence of moribund/fresh-dead 92 brood year Carson spring chinook salmon juveniles with clinical levels of Rs antigen (>1.000 OD units) as determined by the ELISA during monthly monitoring from August 1993 through February 1994. The fish were from four Oregon raceways at Umatilla Hatchery.

Table 1. Prevalence and proportion of moribund/fresh-dead 92 brood year Carson spring chinook salmon juveniles with clinical levels of Rs antigen (>1.000 OD units) as determined by the ELISA during monthly monitoring from August 1993 through February 1994. The fish were from Oregon raceways (04A, 04B, 05A and 05B) at Umatilla Hatchery. The differences between the 04 and 05 series of raceways were statistically significant ($p \leq 0.017$).

	Fish with Clinical Levels of Rs Antigen	
Raceway	Prevalence (%)	Proportion
04A	43.3	13/30
04B	43.8	14/32
05A	62.5	20/32
05B	51.5	17/33

Juvenile Preliberation Monitoring

External parasites were not detected in wet mounts of gill or body scrapings examined by microscopy from a total of 40 fish. Gill condition was normal by gross examination. No culturable viral agents were detected by cell culture assays. One-thousand two-hundred blood smears from chinook salmon stocks at Umatilla Hatchery were negative for EIBS inclusions. At Bonneville Hatchery, 1.7% (1/60) of the 92 brood year Carson spring chinook salmon, scheduled for release as yearlings. had a low level (1-2 inclusions per microscope field) of typical EIBS inclusions.

Assays for *Renibacterium salmoninarum* by the ELISA

Three of 90 Umatilla summer steelhead (91.93) juveniles tested for Rs by the ELISA had OD readings greater than 0.100; one of these had a moderate level of antigen at 0.454 OD units and the other two were only slightly greater than 0.100 (Appendix Table A-19) Mean OD's for the 30 fish from each raceway were 0.028, 0.019 and 0.027 for M5A, M5B and M5C, respectively.

One of 120 (0.8%) 93 brood year Priest Rapids-Umatilla fall chinook salmon juveniles from four Oregon raceways had an OD reading greater than 0.200 (0.397); 2/180 (1.1%) in six Michigan raceways had readings greater than 0.200 (0.215 and 0.233) (Appendix Table A-20). Four fish in Oregon raceways had readings in the range of 0.100-0.199 and nine in Michigan raceways were in this range. Mean OD readings for the 30 fish from each Oregon raceway were 0.022. 0.043, 0.068 and 0.033 for O2A. O2B, O3A and O3B, respectively. For the six Michigan raceways mean OD's were 0.036. 0.050, 0.056. 0.030. 0.019 and 0.054 for M2A, M2B, M2C, M3A, M3B and M3C, respectively. Kidneys from these fish were processed at a 1:15 dilution because of their small size.

In 93 brood year Carson spring chinook salmon, scheduled for release as subyearlings, 1.1% (2/180) from six Michigan raceways had OD readings between 0.200 and 0.299. and 1.1% (2/180) were in the 0.100-0.199 range (Appendix Table A-21). These four fish with OD values greater than 0.100 were in raceways M7B and M7C. Mean OD by raceway was 0.030, 0.033, 0.024. 0.042. 0.034 and 0.040 for M6A, M6B, M6C, M7A, M7B and M7C, respectively.

The 93 brood year Carson spring chinook salmon juveniles, scheduled for release as yearlings. in four Oregon and six Michigan raceways had even lower ELISA OD ranges (Appendix Table A-22). Two-percent (6/300) were in the 0.100-0.199 range and the remaining 98% (294/300) had readings less than 0.100. The means ranged from a low of 0.020 in O2A. to a high of 0.053 in M2A. The means for fish in the two lower Michigan raceways which had experienced increased losses to BKD in September, were 0.034 and 0.028 for M2C and M3C, respectively.

The ELISA distributions from the 92 brood year Carson spring chinook salmon, scheduled for fall release, were evaluated in several ways. The ELISA data for the two 30-fish sample groups from each raceway are shown in Appendix Table A-24 (ELISA values in ascending order for the complete 60 fish from each raceway are shown in Appendix Table A-23). First, within raceway comparisons between the two 30-fish sample groups from each of the ten raceways were made--it should be recalled that kidneys from sample group 1-30 were taken from freshly sacrificed and bled fish while those from 31-60 were from frozen, unbled carcasses. Using a two-tailed t-test, no statistical differences were found between the two 30-fish sample groups in eight of the ten raceways ($\alpha = 0.05$). In two raceways (03B and M2C), however, the mean ELISA OD of sample group 1-30 was statistically higher than that of the second sample group designated 31-60. *P* values for these two raceways were 0.046 and 0.013 for 03B and M2C, respectively.

Second, comparisons of ELISA data were made using comparable 30-fish sample groups in upper Oregon and Michigan raceways. No statistical differences were found among either Oregon or Michigan raceways using the first 30-fish sample group. Using the second sample group, however, a statistical difference was found in raceway 02B among the Oregon raceways ($p \leq 0.0151$). No differences were found among Michigan raceways using the second sample group. The incidence of clinical Rs in raceway 02B appeared to be no different for this raceway during monthly monitoring nor was the mortality rate different than for the other Oregon raceways.

Third, comparisons of ELISA data were made using comparable 30-fish sample groups in upper Oregon and Michigan raceways, and in lower Oregon and middle Michigan raceways. No differences were found between upper Oregon and Michigan raceways using either sample group. ANOVA among the lower Oregon and middle Michigan raceways, however, indicated that 02B was significantly different with both sample groups ($p \leq 0.0010$ for both sample groups). Thus, there is statistical evidence that 02B had a lower ELISA distribution than the other three Oregon raceways and the six Michigan raceways at liberation.

The ELISA values obtained with 92 brood year Carson spring chinook salmon yearlings in four Oregon raceways and two Michigan raceways were predominantly at or below 0.100 (Appendix Table A-12). Ninety-three percent (279/300) were in this very low range. Of the remaining 21 fish, five (1.7%) were in the 0.100-0.199 range, nine (3.0%) were in the 0.200-0.399 range, four (1.3%) had readings in the 0.400-0.599 range. and three (1.0%) had clinical levels greater than 1.000 OD units. Means for the two Michigan raceways were 0.023 for M5A and 0.085 for M5B.

Significant statistical differences ($p \leq 0.00009$) were found between the log-transformed mean ELISA values for the fall release and the yearlings of the 92 brood year Carson spring chinook salmon at preliberation sampling. The fall release fish had a significantly higher log-transformed mean (-0.9249) than the spring release yearlings (-1.4657). The non-transformed means for these two populations were 0.227 and 0.067 for the fall release and yearlings, respectively.

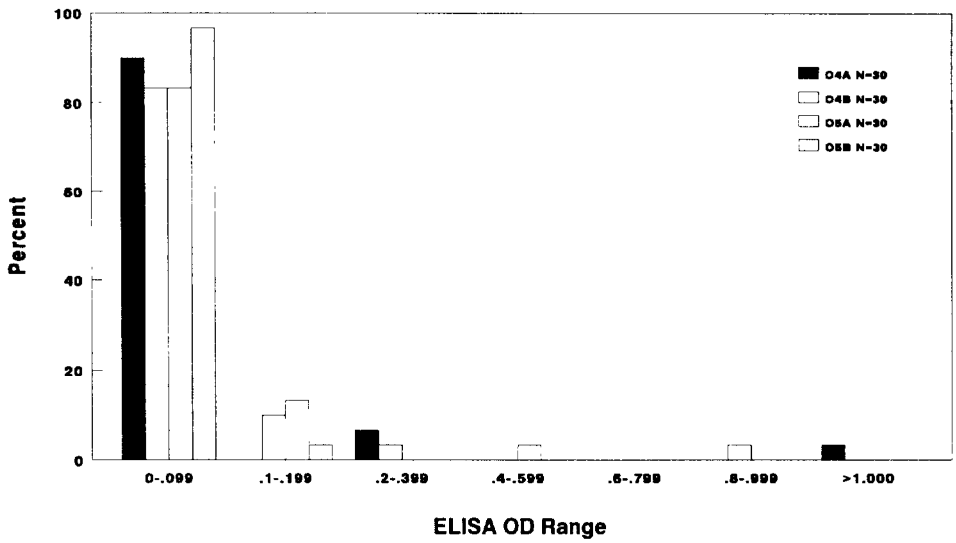


Figure 2. Percent distribution of preliberation ELISA OD_{405} ranges of 120 spring chinook salmon, 92 brood year released as yearlings, sampled from four Oregon raceways (04A, 04B, 05A and 05B) at Umatilla Hatchery on 3-15-94.

Conversely, the 92 brood year Carson spring chinook salmon scheduled for yearling release at Bonneville Hatchery, had a very narrow range of readings at the very low end of the ELISA spectrum (Appendix Table A-26). The highest OD value was 0.217 with five others (8.3%) in the 0.112-0.154 range. The remaining 90% (54/60) had OD values less than 0.100.

Juvenile Disease Outbreak Monitoring

Responses to increased losses at Umatilla Hatchery were made on 20 October 1993, on 31 December 1993 and on 12 September 1994; all for Carson spring chinook salmon juveniles. Results of a BKD outbreak which began in the 92 brood year Carson spring chinook salmon, scheduled for fall release, in July of 1993 are also included in this annual report because the conclusion of this episode was not until the fish were released November of 1993. Details of this were presented at the 45th Annual Northwest Fish Culture Conference held at Sunriver, Oregon on 6-8 December 1994 under a presentation entitled "Lack of evidence for horizontal transmission of *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease, among raceways of juvenile spring chinook salmon at Umatilla Hatchery" (Groberg et al. 1994). Monthly monitoring data of 122 moribund/fresh-dead fish of this stock from July through October 1993 revealed that 63% of these had very high-to-clinical ranges of Rs antigen as measured by the ELISA (Figure 3). Analyses of the cumulative percent mortality during September and October of 1993 while they were in four Oregon (02A, 02B, 03A and 03B) and six Michigan (M2A, M2B, M2C, M3A, M3B and M3C) raceways showed only slight differences among Oregon raceways and among Michigan raceways (Table 2). An assumption was made, then, that any differences were random, and the mean of Oregon raceways was compared to that of Michigan raceways (two-tailed t-test). This revealed a significant difference between the means of the cumulative percent mortality in Oregon (mean = 1.28%) and Michigan (mean = 2.54%) raceways during these months (p = 0.00003).

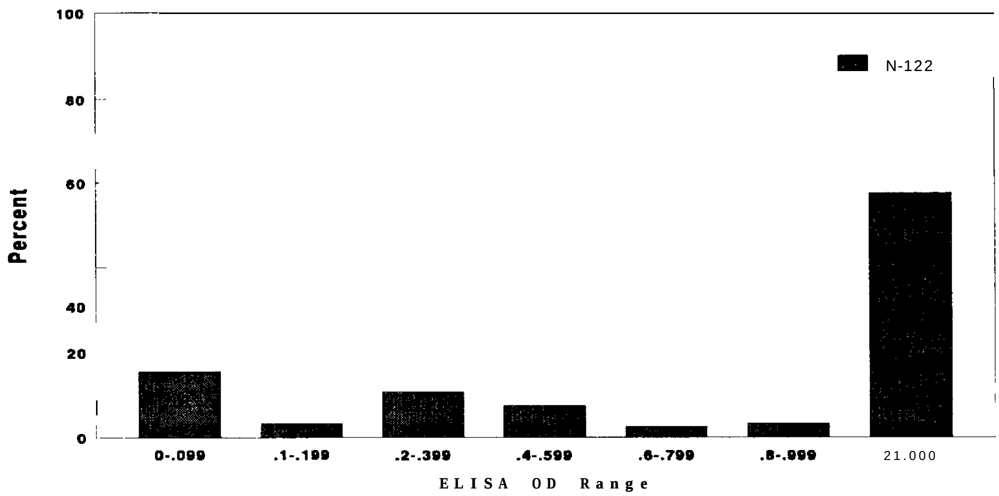


Figure 3 Percent distribution of ELISA OD_{405} values obtained during monthly monitoring from 122 moribund/fresh-dead 92 brood year Carson spring chinook salmon juveniles, scheduled for fall release, at Umatilla Hatchery from July through October 1993.

Table 2. Cumulative percent mortality in 92 brood year Carson spring chinook salmon juveniles scheduled for fall release from four Oregon (02A, 02B. 03A and 03B) and six Michigan (M2A, M2B, M2C, M3A, M3B and M3C) raceways at Umatilla Hatchery during September and October of 1993. An assumption was made that there were no significant differences in cumulative percent mortality among Oregon raceways or among Michigan raceways. Means of this mortality for Oregon and Michigan raceways are at the bottom of the columns. These were determined to be significantly different using a two-tailed t-test ($p \leq 0.00003$).

Oregon Raceway	Cumulative Percent Mortality	Michigan Raceway	Cumulative Percent Mortalitv
02A	1.38	M2A	2.33
02B	1.14	M2B	2.90
03A	1.23	M2C	2.30
03B	1.39	M3A	2.63
		M3B	2.85
		M3C	2.22
Mean	1.28	Mean	2.54

The 20 October 1993 episode involved the 92 brood year juveniles, programed as yearlings, while they were in four Oregon raceways (04 and 05 series). Kidney pustules typical of BKD were observed in 88% (44/50) of the moribund/fresh-dead fish examined on that date. Monthly monitoring during September 1993 had indicated an increasing prevalence and severity of Rs infections (Figure 1). Increasing losses to BKD were then observed in early October (Figure 4). An amended. INAD application for erythromycin therapy was immediately submitted to Christine M. Moffitt of the University of Idaho to allow for an unscheduled feeding of the antibiotic. A 21-day regimen was begun on 5 November 1993 and completed on 26 November 1993 (Figure 4). The daily losses decreased to near-normal levels by December and through the remaining months of hatchery rearing.

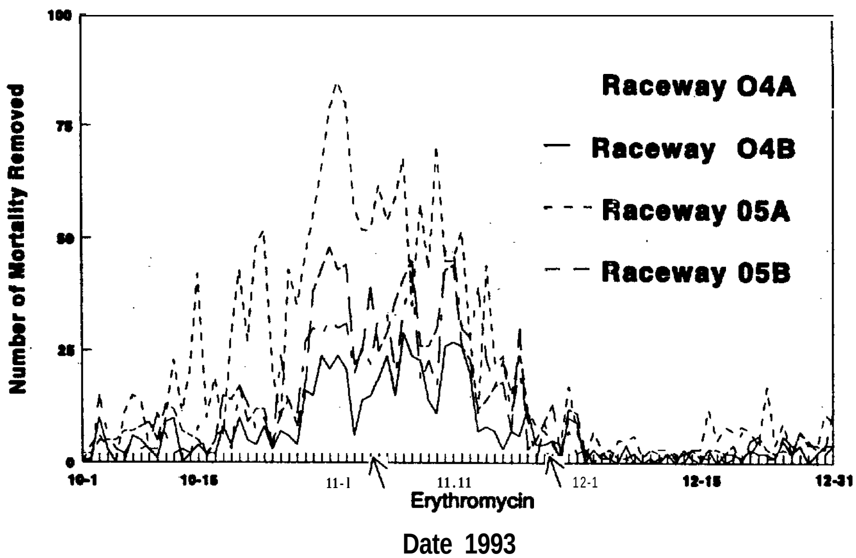


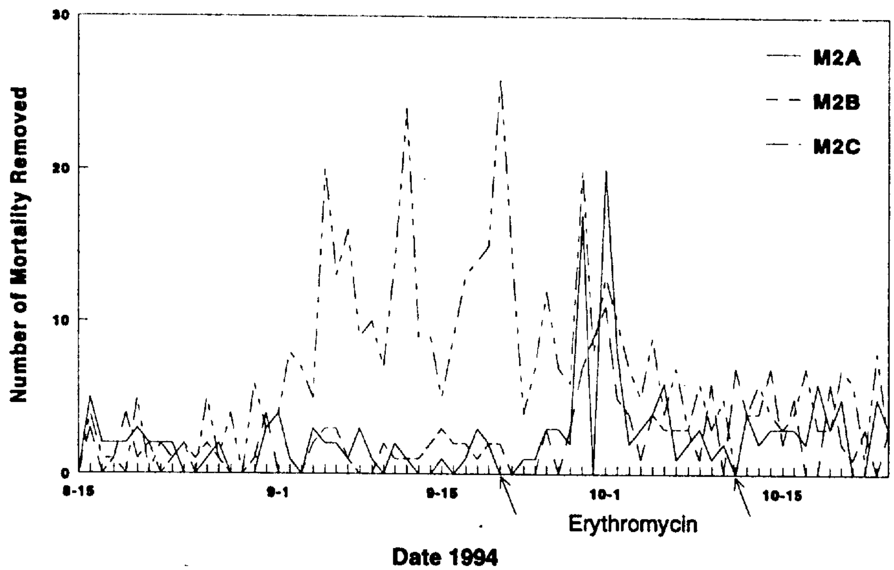
Figure 4. Numbers of 92 brood year juvenile spring chinook salmon mortality'removed daily from four Oregon raceways (O4A, O4B, 05A and O5B) at Umatilla Hatchery between lo-1-93 and 12-31-93. Dietary erythromycin therapy for BKD was administered daily for 21 days from 11-5-93 to 1-1-26-93 at a target drug dosage of 92 mg/kg body weight of fish/day, The arrows indicate the start and the end of the erythromycin therapy.

On 31 December 1993 five moribund 93 brood year Carson spring chinook salmon juveniles from Oregon raceway O1B were examined. These had been split from O1A on 22 December 1993 and the loss in O1B increased approximately one week later. Four of five fish had high levels of motile bacteria on their gills as determined by microscopic examination and culture on media. No treatments were recommended because this appeared to be a phenomenon of post-handling stress. Losses abated to normal levels within a few days.

Carson 93 brood year spring chinook salmon juveniles programmed for fall release were examined on 12 September 1994 because of increased losses. These were in four Oregon raceways (O1 and 02 series) and six Michigan raceways (M2 and M3 series) at this time. The elevated losses during early September occurred only in the lower Michigan raceways of each series (Figure 5). Typical BKD pustules in the kidney were observed in 100%(10/10)of the moribund/fresh-dead fish from lower Michigan raceway M2C, and in 80% (4/5) of the moribund/fresh-dead fish from lower

Michigan raceway M3C. Pustules were not observed in any of four fish examined from middle and upper Michigan raceways nor in two from Oregon raceways. The ELISA results, once again, verified the gross observations; the 10/10 fish from M2C and 4/5 from M3C were well into the clinical range (1.610-2.610). One moribund/fresh-dead fish from M3A also had a reading in this range (2.425). Values for the others were 0.012, 0.102. 0.261, 0.304 and 0.699--it is noteworthy, that during monthly monitoring in August, swollen 'kidneys or pustules were recorded in 90% (9/10) of the moribund/fresh-dead fish taken from M2C and M3C. These fish were scheduled for a second and final erythromycin feeding in October under an INAD permit. Because of this outbreak of BKD. this 21-day treatment regimen was advanced to begin on 20 September 1994 and end on 10 October 1994 (Figure 5). The target drug dosage was 100 mg/kg of fish body weight/day. The cumulative percent mortality for both Oregon and Michigan raceways during September 1994 and from l-24 October 1994--they were transferred to acclimation ponds on 25-27 October 1994--were compared (Table 3). The higher mortality rates for the two lower Michigan raceways (M2C and M3C) during September are clearly higher that all others (Figure 5 and Table 3). There is no indication of higher rates in the middle Michigan B raceways over that of the upper Michigan A raceways in a series.

There was also a trend toward higher mortality rates during October, over that in September, in raceways OlA, 02A. 02B, M2B, M3A and M3B (Table 3). This pulse in mortality, before their transfer to acclimation ponds in October, does not appear to be Rs-associated as it was for the two lower Michigan raceways, however, for several reasons. First, monthly monitoring was conducted on 27 September 1994. 15 days subsequent' to the loss investigation. None of the 36 moribund/fresh-dead fish sampled from raceways other than M2C and M3C showed signs consistent with BKD (two were precocial males>. Assays of these by the ELISA produced no evidence that Rs infections were predominant among these (Appendix Table A-16). Only four of these 36 even had Rs antigen levels as high as the moderate CID range (0.306-0.696). Second. preliberation ELISA data of grab-sampled fish on 18 October 1994 (Appendix Table A-22) indicate that 98% (294/300) of these had OD values less than 0.100. and the other 2% (6/300) were in the 0.100-0.199 range: thus there was no indication that Rs infections were either widely distributed or at high leveis among these populations--it is important to note, however, that the fish had completed a 21-day erythromycin regimen on 10-10-94. eight days prior to the preliberation sampling. And finally, a preliberation examination of this stock on 9 November 1994 following their transfer to acclimation ponds at Imeques C-mem-ini-kern on the upper Umatilla River, indicated that 10% (2/20) of grab-sampled fish had ELISA DD values between 0.300 and 0.500. The other 18 had readings less than 0.150. Even among 16 moribund/fresh-dead fish from these acclimation ponds, the highest OD value obtained was 0.476, well below values that appear to be associated with mortality. The onset of this October mortality kas actually in late September (Figure 5), very near the time erythromycin therapy began on 20 September. It is unlikely, therefore, that erythromycin would have prevented this mortality, even if it was Rs-associated.



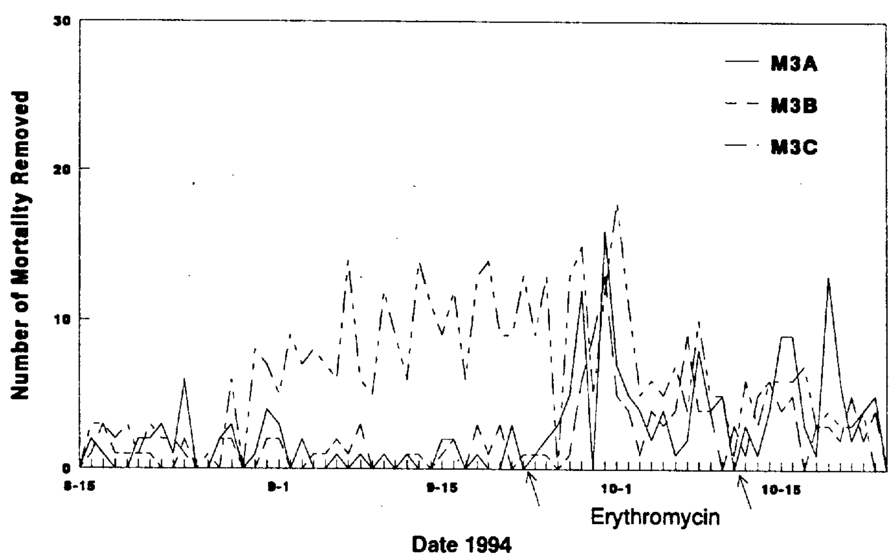


Figure 5. Numbers of 93 brood year juvenile spring chinook salmon mortality removed daily from Michigan raceway series M2 (upper graph) and Michigan raceway series M3 (lower graph) at Umatilla Hatchery between 8-15-94 and 10-24-94. Dietary erythromycin therapy for BKD was administered daily for 21 days from 9-20-94 to 10-10-94 at a target drug dosage of 100 mg/kg body weight/day. The arrows indicate the start and end of the erythromycin therapy.

Table 3. Percent mortality-in 93 brood year Carson spring chinook salmon juveniles, scheduled for fall release, from four Oregon (O1A, O1B, O2A and O2B) and six Michigan (M2A, M2B, M2C, M3A, M3B and M3C) raceways at Umatilla Hatchery during September and October (lo-l-94 through 10-24-94) 1994. The September mortality rates for M2C and M3C were determined to be significantly different than for the A and B raceways in their respective series (Chi-square, $p \leq 0.0001$).

Oregon Raceway	Monthly Mortality (%) September	Monthly Mortality (%) October	Michigan Raceway	Monthly Mortality (%) September	Monthly Mortality (%) October
O1A	.09	.16	M2A	.19	.18
O1B	.15	.14	M2B	.15	.19
O2A	.13	.22	M2C	.79	.29
O2B	.16	.24	M3A	.14	.25
			M3B	.14	.20
			M3C	.68	.32

Broodstock Monitoring

The Umatilla summer steelhead broodstock providing eggs for the 94 brood year steelhead at Umatilla Hatchery were again negative for replicating agents by cell culture assays. Individual sex fluid samples from 100% of the females (48) and males (48) spawned were tested for IHN virus. Two or three-fish tissue pools from the 71 fish killed at spawning were also screened. All 71 killed and spawned adults (Appendix Table A-271, and 16 adult mortality (Appendix Table A-28) were sampled for Rs by the ELISA. One spawned female had on OD reading in clinical range (1.348) and two others were in the moderate range (0.480 and 0.409); all others were less than 0.137. All of the mortality had readings less than 0.056.

Adult brood stock providing eggs for the 93 brood year fall chinook salmon at Umatilla were spawned at Priest Rapids on 8 and 15 November 1993, and at Minthorn Ponds between 4 and 23 November 1993. One-hundred twenty individual ovarian fluid samples from females at Priest Rapids (Appendix Table A-29) and 174 individual sex fluid samples from females and males at Minthorn (Appendix Table A-31) were assayed for IHN virus on cell cultures-: all were negative. Twenty-five tissue sample pools (two females per sample) from Minthorn females were assayed for culturable viruses and negative. One-hundred fifty-eight fish at Minthorn were examined for EIBS and found negative. Sixty females at Priest Rapids tested for Rs by the ELISA had OD values less than 0.100 (Appendix Table A-30,). All 174 fish spawned at Minthorn were also tested by the ELISA (Appendix Table A-32); one female and four males were in the 0.200-0.399 OD range, one female and 14 males were in the 0.100-0.199 range, and the remaining 154 fish had readings below 0.100.

Fall chinook salmon adult females at Bonneville for Bonneville Hatchery 93 brood year production were sampled between 1 November and 9 December 1993 for IHN virus. Sixty-eight of 361 (18.8%) three-female ovarian fluid sample pools were positive for IHN virus (Appendix Table A-34). Twelve five-female pooled tissue samples taken on 1 November'1993 were negative for culturable viruses. Samples for EIBS were taken from 15 females and 15 males on each spawning date from 1 November to 2 December 1993 (Appendix Table A-33). The females were negative and 10.7% (8/75) of the males had typical EIBS inclusions. Under requirements of another BPA funded project, 2552 kidney samples from the fall chinook salmon spawned at Bonneville between 1 November and 2 December 1993 were assayed by the ELISA for Rs (Appendix Table A-35). By OD range, the percent distribution of these is as follows: 0.35% >1.000, 0.08% = 0.800-0.999, 0.86% = 0.600-0.799, 0.31% = 0.400-0.599, 0.27% = 0.200-0.399, 1.10% = 0.100-0.199, and 97.02% = 0.000-0.099.

Eggs for Umatilla Hatchery. 93 brood year spring chinook salmon production were from the Carson spring chinook salmon adults spawned at Carson National Fish Hatchery between 9 and 30 August 1993. Viral sampling between 8 August and 1 September 1993 indicated that 64.4% (172/267) of individual ovarian fluid samples were IHN virus positive and 8.8% (12/137) of milt samples tested were'positive for the virus (Appendix Table A-36). Twelve of 12 five-female tissue samples taken on 11 August also tested IHN virus positive. Eighty females assayed for EIBS were negative and kidneys from these same fish were assayed for Rs by the ELISA (Appendix Table A-38). The highest OD readings from these were only 0.173 and 0.289 for two females spawned on 9 and 16 August, respectively., The other 78 were below 0.100 OD units.

Investigational New Animal Drug Monitdring

Signs associated with erythromycin toxicity were observed in the 92 brood year spring chinook salmon yearlings following the amended INAD feeding they received in October-November of 1993. On the day-l test of 30 fish in O4A, three showed toxic signs defined in the INAD toxicity test protocol. On the day-14 test, two of 30 from O4A and one of 30 from O5A also were recorded as showing possible signs of toxicity. In the 93 brood year chinook salmon scheduled for fall release, toxic reactions were noted in four of 60 fish on the day-l test following their pre-release feeding in October 1994.

DISCUSSIDN

The relative lack of serious, survival-impairing infectious diseases in- fish reared at Umatilla Hatchery during the initial rearing cycles was not a fortunate circumstance during, and for some months prior to, the period of this annual report. Infections in two consecutive brood'years of spring chinook salmon by Rs resulted in BKD among these populations. The focus of this discussion, therefore, will primarily concern the details and analyses of these events. Comments relative to other pathogens-and parasites, however, will be addressed first.

There was a continued and total void of external parasites on fish at Umatilla Hatchery: none were observed on 708 fish examined this year. This is attributed to functional anti-bird netting and an enclosed well water supply. *Flexibacter psychrophilus* was the only systemic bacterial pathogen other than Rs detected: predominantly in the steelhead. and second most frequently in the fall chinook salmon. There was no evidence for measurable loss to the CWD bacterium in any group of fish at Umatilla. Inclusions possibly associated with EIBS infection were seen in four moribund chinook salmon. These inclusions were at very low levels in fish with other infections or maladies. In these cases, the blood picture is often abnormal with debris that can confuse a presumptive EIBS diagnosis. The failure to find any inclusions in blood smears from 1.407 grab-sampled chinook salmon tends to create doubt that EIBS occurred in fish at Umatilla. Also, to date, no definitive cases of typical bacterial gill disease have been diagnosed. Occasional pulses of loss associated with handling fish and subsequent invasion of the gills by bacteria have been identified: These have been minor and short-lived.

For the third consecutive year, spring chinook salmon reared at Llmatilla were progeny of adults at Carson National Fish Hatchery that had very high prevalences of IHN virus. There has been no loss in these progeny suggesting IHN virus infection, nor has the virus been isolated during preliberation monitoring. The total number of spring chinook salmon juveniles reared at Umatilla under this scenario now numbers 3.8 million. So although there continues to be reasonable suspicion that the virus is vertically transmitted in certain circumstances (Meyers et al. 1990). there is a mounting body of evidence indicating that, in most cases, the benefit of rearing progeny from IHN virus positive parents may well outweigh potential risks.

The episode of BKD in the 92 and 93 brood year spring chinook salmon produced very disparate clinical courses and epidemiological profiles. These will be discussed in sequence and comparisons between the two brood years will be made.

During only their second month of rearing in raceways, the 92 brood year spring chinook salmon programmed for fall release in 1993 were already experiencing clinical BKD. This was evidenced by extremely high ELISA readings in 20% of the moribund/fresh-dead fish sampled during monthly monitoring in June 1993 (Appendix Table A-17). There was a month-to-month progression in the prevalence of clinical ELISA readings, such that by October, 52% of monthly mortality were in the clinical range--there was actually a peak in September at 77.8% (Figure 6). Over the same time, ELISA values throughout-the range were also increasing.

A similar pattern was documented in this stock programmed to be yearlings in the spring of 1994 (Figure 6). Two months after they were ponded in July, 50% of the moribund/fresh-dead had clinical ELISA values (Appendix Table A-18). This peaked at 95% in October and remained between 40 and 55% from November 1993 to February 1994. The fall release fish received erythromycin therapy in October and the Spring release were fed the antibiotic in November 1993 and February 1994. Undoubtedly, erythromycin contributed to the lower percentages of clinical BKD following the peak months of September and October for the fall release'and yearlings, respectively--it did not, however, even-approach eliminating the BKD mortality.'

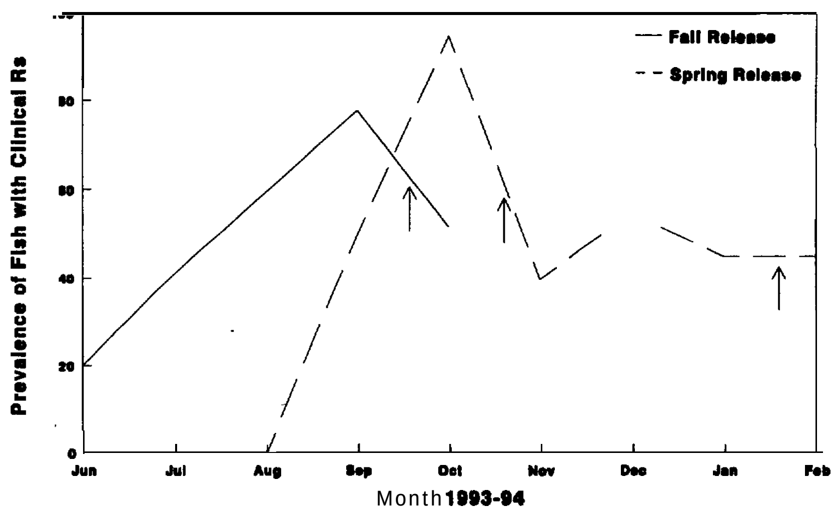


Figure 6. Prevalence (%) of moribund/fresh-dead 92 brood year Carson spring chinook salmon juveniles with clinical levels of Rs antigen (>1.000 00 units) as determined by the ELISA during monthly monitoring from June 1993 through February 1994. The arrows indicate the beginning of dietary erythromycin therapy.

Comparisons of the preliberation ELISA data between the fall and spring release groups of the 92 brood year spring chinook salmon all indicate a greater severity of Rs infections among the fall release fish at the time of their liberation. The log-transformed mean ELISA OD for the 120 spring yearlings was -1.4657, significantly lower than that for the fall release fish with a mean of -0.9249: Further, evidence for differences in these populations is shown by a shift in the bars of the ELISA distribution values to the right in the ELISA spectrum for the fall release fish and a far less percentage of fish in the 0-0.099 range (Figure 7). It should also be noted that the fall release fish were tested 18 days' following their last erythromycin treatment and the yearlings were evaluated 31 days after treatment. Masking of Rs infection levels from treatment, therefore, would have been greater in the fall release group.

Preliberation sampling of the fall release population was used to evaluate the sampling methodology used for the fish health monitoring project. This particular population was selected because there was a wide variation in the distribution of. Rs antigen within the population. Included were comparisons between two 30-fish sample groups from each of ten raceways and comparisons between kidney samples taken from fresh and frozen carcasses. Differences between 30-fish sample groups from the same raceway were found in five of ten raceways: O2A, O2B, O3B, M2B and M3A. Examination of the data suggests that these differences can be attributed to random sampling variation and were not related to taking kidneys from fresh or frozen carcasses. Had this significantly contributed to differences in the ELISA values obtained, statistical differences would have been expected in nearly all of the ten raceways.

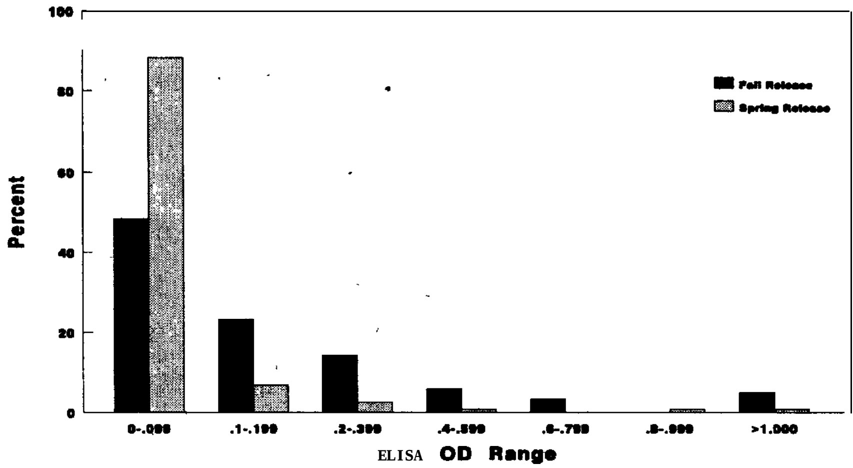


Figure 7'. Distribution of ELISA 00485 values obtained during preliberation monitoring of grab-sampled 92 brood year Carson spring chinook salmon juveniles scheduled for either fall or spring release. The bar graphs were generated using the ELISA data from the 120 samples from the spring release fish shown in Appendix Table A-25 and from 120 samples designated 1-30 of the fall release fish from Oregon raceways O2A-B and O3A-B in Appendix Table A-24.

Conclusions from the 92 brood year Carson spring chinook salmon rearing evaluations relative to Rs infection and BKD are: 1) There were significantly higher mortalities in Michigan raceways over that in Oregon raceways for the fall release fish: 2) there were no significant differences in mortality'rates between upper. middle and lower Michigan raceways nor between upper and lower Oregon raceways for the fall release fish, and: 3) at release, the fall release fish had higher levels and'prevalences of infection than did the yearling spring release fish.

In contrast to the 92 brood year Carson spring chinook salmon in which clinical BKD was first seen in June, the disease was first detected in the 93 brood year fish in August (Appendix Table A-16). Twenty-four percent of the moribund/fresh-dead fish tested during monthly-monitoring had clinical BKD in August, and 16% had similar levels in September. Significantly, clinical BKD in these fall release 93 brood year populations was only observed in one fish from a lower Oregon raceway (O1B), and in 16 fish from two lower Michigan raceways (M2C and M3C) (Appendix Table A-16). Conversely, the 92 brood year fish showed no differences in the distribution of clinically infected fish among all raceways.

Preliberation ELISA data from the 93 brood year Carson spring chinook salmon scheduled for fall release from each of the four Oregon and six Michigan raceways in October indicate there were no differences in Rs antigen among fish in all ten raceways (Appendix Table A-22) This contradicts what might have been expected considering the apparent high prevalences of clinically infected fish only in lower Michigan raceways in August and September. This may be explained, in part. by the fact that these fish received a 21-day erythromycin regimen that was completed eight days prior to this preliberation evaluation. Possible differences in infection rates between raceways may have been somewhat masked by this treatment; investigations comparing ELISA before and after erythromycin therapy are ongoing. Analyses of the yearlings of this brood year will be presented in the next annual report and these data may contribute to understanding the epidemiology of Rs infection in the 93 brood. The data from monthly monitoring of moribund/fresh-dead fish, however, strongly suggests there was an increased severity of BKD in the lower Michigan raceways.

The different clinical courses of the BKD in the 92 and 93 brood year Carson spring chinook salmon reared-at Umatilla can be traced back to the Rs status of the adults spawned at Carson National Fish Hatchery.- Figure 8 depicts the Rs distributions by ELISA OD values for those two brood years. Over twenty-five percent of a subsample of 41 females spawned for the 92 brood year had OD's greater than 0.800: Females with these levels of antigen are known to vertically transmit the infection to their progeny. None of the subsample of 80 females contributing eggs to the 93 brood were in these antigen ranges: in fact. they were all at the opposite end of the spectrum where vertical transmission would not be expected. These subsamples represent approximately 10 and 20% of the females spawned for Umatilla production in brood years 92 and 93, respectively.

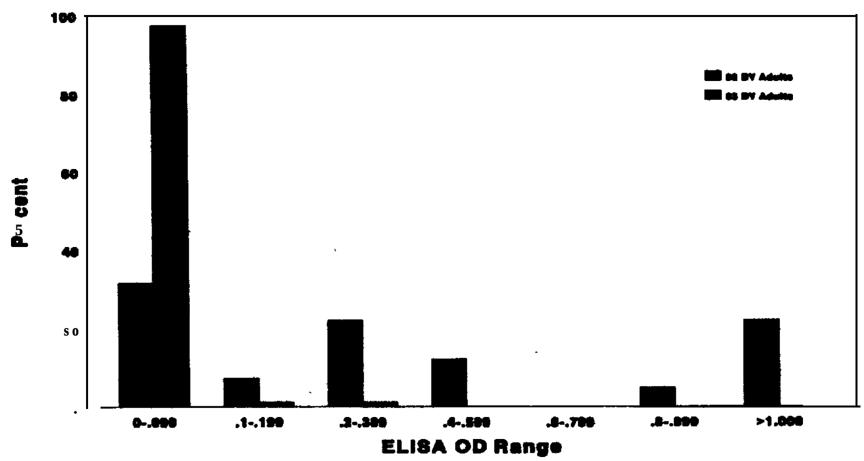


Figure 8. Percent distribution of ELISA OD_{405} values obtained from subsamples of spawned females providing eggs for the Umatilla Hatchery spring chinook salmon production in brood years 92 and 93. Adults were spawned and kidneys taken for ELISA at Carson National Fish Hatchery. Forty-one females were sampled in the 92 brood year and 80 were tested in the 93 brood year. Data from which these bar graphs were generated are in Appendix Table A-35 of the 1993 annual report (Keefe et al. 1994) and in Appendix Table A-38 of this report.

The early and widespread onset of clinical BKD in the 92 brood year juveniles is undoubtedly linked vertically to the high percentage of maternal parents with high Rs antigen levels. Any horizontal transmission that occurred during rearing at Umatilla may have been overwhelmed by the high degree of vertical transmission which occurred. The BKD in the 93 brood year juveniles must either be linked to high Rs -antigen females not represented in the subsample, or to vertical transmission from low Rs antigen females. The former alternative seems more plausible given the very low levels of antigen in the subsampled population. The later onset of the BKD in the 93 brood juveniles may indicate that the Rs levels in the contributing adult females were in intermediate ELISA ranges (i.e. 0.400-0.800 OD units). This scenario also better explains the increased severity of BKD in lower Michigan raceways as a result of possible horizontal transmission and/or higher stress levels in these raceways.

-The BKD episode in the 92 brood year Carson spring chinook salmon raised questions concerning the host-pathogen-environment interaction of Rs and its salmonidhosts. Considering the high prevalences and levels of Rs in these juveniles and the configuration of the three tandem Michigan raceways, increasing Rs associated mortality and increasing severity of infection would be expected from the A. to the B. to the C raceway if horizontal transmission was occurring--this would be particularly true if the fish in the lower raceways were more stressed. Neither of these proved to be the case. The question then becomes, what is the efficiency of horizontal transmission of Rs between juvenile spring chinook salmon at Umatilla Hatchery, as well as other fish culture facilities? There is some suggestion from analyses of the data from this case that susceptible fish become infected and develop clinical disease, or they are not susceptible and do not become infected at all. Indeed, a recent study showed that coho eggs injected with a soluble antigen (p57) from Rs prior to fertilization were more far more susceptible to infection by the bacterium when challenged as juveniles than juveniles that were progeny from Rs negative females (Brown 1994). In the same study, an assay to measure the activity of phagocytic'cells from both groups of fish against Rs showed almost no activity in cells derived from the antigen treated group. If similar-effects resulted from vertical transmission of the whole bacterium from maternal parent to her progeny, it would mean that both the viable bacterium and enhanced susceptibility to it would passed on to the progeny. Such a model could, to some degree, explain the observations made in the 92 brood year Carson spring chinook salmon at Umatilla Hatchery. The ongoing studies at Umatilla and other locations will continue to explore these possibilities.

ACKNOWLEDGMENTS

Personnel from the Oregon Department of Fish and Wildlife Fish Pathology , Laboratories at Clackamas and Corvallis provided technical support for some of the Umatilla Fish Health Monitoring and Evaluation activities. The data in Appendix Table A-35 was collected and provided by the Corvallis laboratory under a separate Bonneville Power Administration project. The success of any project conducted at a hatchery depends on the assistance of a professional and dedicated hatchery crew and acknowledgment to the Umatilla Hatchery crew is given in this regard. Dr. Richard Ettinger of Eastern Oregon State College provided valuable assistance with statistical analyses.

LITERATURE CITED

Brown, L. L. 1994. Vertical transmission of pathogens and immunity in salmonids. . Ph.D. Thesis. University of British Columbia, Vancouver, British Columbia.

Keefe. M. L., R. W. Carmichael, R. A. French, W. J. Groberg and M. C. Hayes. 1993. Umatilla Hatchery monitoring and evaluation. Annual Report for Project Number 90-005. Bonneville Power Administration, Portland, Oregon.

Keefe. M. L., R. W. Carmichael, S. M. Focher, W. J. Groberg and M. C. Hayes. 1994. Umatilla Hatchery monitoring and evaluation. Annual Report for Project Number 90-005. Bonneville Power Administration, Portland, Oregon.

Groberg. W. J., Jr., N. L. Hurtado, S. T. Onjukka and K. Waln. 1994. Lack of evidence for horizontal transmission of *Renibacterim salmoninarum*, the causative agent of bacterial kidney disease, among raceways of juvenile spring chinook salmon reared at Umatilla Hatchery: *In* Proceedings of the 45th Annual Northwest Fish Culture Conference. Sunriver, Oregon.

Meyers, T. R., J. B. Thomas, J. E. Follett and R. R. Saft. 1990. Infectious hematopoietic necrosis virus: Trends in prevalence and the risk management approach in Alaskan sockeye salmon culture. Journal of Aquatic Animal Health 2:85-98.

APPENDIX A

Appendix Table A-1. Number of 93 brood year Umatilla summer steelhead juveniles sampled per raceway in Oregon series 1 (O1A and O1B) and Michigan series 5 (M5A, M5B and M5C) during monthly monitoring.

Date sampled	O1A[1]	O1A[2]	O1B[1]	O1B[2]	M5A[1]	M5A[2]	M5B[1]	M5C[1]	M5C[2]
09-93	10	10							
10-93	5		1	5					
11-93					1		2	0	5
12-93					5		3	5	5
01-94					1		1	0	5
02-94					5		4	5	5
03-94					5	5			

1 *Moribund or fresh-dead fish.*
2 *Normal, healthy appearing fish.*

Appendix Table A-2. Number of 93 brood year Priest Rapids-Umatilla fall chinook salmon juveniles sampled per raceway in Oregon series 2 and 3 (O2A, O2B, 03A and O3B) during monthly monitoring.

Date sampled	O2A[1]	O2B[1]	O2B[2]	O3A[1]	O3B[1]	O3B[2]
02-94	5	5	5	5	5	5
03-94	5	5	5	5	4	5

1 *Moribund or fresh-dead fish.*
2 *Normal, healthy appearing fish.*

Appendix Table A-3. Number of 93 brood year Carson spring chinook salmon juveniles, released as subyearlings. sampled per raceway in Oregon series 1 (O1A and O1B) and in Michigan series 6. 7 and B (M6A, M6B, M6C, M7A, M7B, M7C, M8A, M8B and M8C) during monthly monitoring.

Date sampled	O1A[1]	O1A[2]	O1B[1]	O1B[2]	M6A[1]	M6B[1]	M6C[1]	M6C[2]	M7A[1]	M7B[1]	M7C[1]	M7C[2]	M8A[1]	M8B[1]	M8C[1]	M8C[2]
12-93	5	5	5													
01-94	5		5	5												
02-94	(Fish being moved among many raceways because of fin clipping)															
03-94					4	5	4	5	4	5	2	5	5	5	5	5

[1] *Moribund or fresh-dead fish.*
[2] *Normal, healthy appearing fish.*

Appendix Table A-4. Number of 93 brood year Carson spring chinook salmon juveniles, released in the fall, sampled per raceway in Oregon series 1 and 2 (O1A, O1B, O2A and O2B) and in Michigan series 2 and 3 (M2A, M2B, M2C, M3A, M3B and M3C) during monthly monitoring.

Date sampled	O1A[1]	O1A[2]	O1B[1]	O1B[2]	O2A[1]	O2B[1]	O2B[2]	M2A[1]	M2B[1]	M2C[1]	M2C[2]	M3A[1]	M3B[1]	M3C[1]	M3C[2]
03-94	4	5													
04-94	5	5													
05-94	5		5	5											
06-94	5		5	5											
07-94	5		5	5								5	5	5	5
08-94	5		5	5	5	2	5	3	5	5	5	5	2	5	5
09-94	5		5	5	4	1	5	5	5	5	5	5	5	5	5

1 Moribund or fresh-dead fish.
2 Normal, healthy appearing fish.

Appendix Table A-5. Number of 92 brood year Carson spring chinook salmon juveniles. released in the fall, sampled per raceway in Oregon series O1, O2 and O3 (O1A, O2A. O2B, O3A and O3B) and in Michigan series M2 and M3 (M2A, M2B, M2C, M3A, M3B and M3C) during monthly monitoring.

Date sampled	O1A[1]	O1A[2]	O2A[1]	O2B[1]	O2B[2]	O3A[1]	O3B[1]	O3B[2]	M2A[1]	M2B[1]	M2C[1]	M2C[2]	M3A[1]	M3B[1]	M3C[1]	M3C[2]
05-93	53	53														
06-93						5	5	5								
07-93			5	5	5	2	5	5								
09-93			5	5	5	5	5	5	5	5	5	5	3	4	3	5
10-93			5	5	5	5	5	5	5	5	5	5	5	5	5	5

1 *Moribund or fresh-dead fish.*
2 *Normal, healthy appearing fish.*
3 *These were combined with the yearling production then split during 8-93 to separate raceways.*

Appendix Table A-6. Number of 92 brood year Carson spring chinook salmon juveniles. released as yearlings. sampled per raceway in Oregon series 4 and 5 (04A. 04B. 05A and 05B) during monthly monitoring.

Date sampled	04A[1]	04A[2]	04B[1]	04B[2]	05A[1]	05B[1]	05B[2]
07-93	5	5					
08-93	5		3	5	4	4	5
09-93	2		4	5	5	5	5
10-93	5		5	5	5	5	5
11-93	5		5	5	5	5	5
12-93	5		5	5	5	5	5
01-94	5		5	5	5	5	5
02-94	5		5	5	5	5	5

[1] *Moribund or fresh-dead fish.*
[2] *Normal. healthy appearing fish*

Appendix Table A-7. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh-dead 93 brood year Lbnatilla summer steelhead during monthly juvenile fish health monitoring.

		Systemic bacterial		Gill bacteria[2]
Date sampled	Raceway	*F. psychrophilus*	APS	
09-93	01A	0/10 (0)	3/10 (30)	0/9 (0)
10-93	01A	0/5 (0)	0/5 (0)	ND[3]
	01B	0/1 (0)	0/1 (0)	ND[3]
11-93	M5A	0/1 (0)	Oil (0)	1/1 (100)[4]
	M5B	2/2 (100)	0/2 (0)	1/2 (50)
	M5C	ND[3]	ND[3]	ND[3]
12-93	M5A	1/5 (20)	1/5 (20)	2/3 (67)
	M5B	2/3 (67)	0/3 (0)	1/1 (100)
	M5C	2/5 (40)	2/5 (40)	1/2 (50)
01-94	M5A	0/1 (0)	0/1 (0)	0/1 (0)
	M5B	0/1 (0)	0/1 (0)	0/1 (0)
	M5C	ND[3]	ND[3]	ND[3]
02-94	M5A	0/5 (0)	0/5 (0)	ND[3]
	M5B	0/4 (0)	0/4 (0)	ND[3]
	M5C	0/5 (0)	0/5 (0)	ND[3]
03-94	M5A	0/5 (0)	0/5 (0)	ND[3]

1 *The only systemic bacteria isolated from kidney smear inocula were* **Flexibacter psychrophilus** *and aeromonad-pseudomonad (APS) types.*

2 *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gill inocula.*

3 *Indicates not done (ND) because no moribund or fresh-dead fish were available.*

4 *The rapid slide agglutination test on 1/6 of these isolates using* **F. psychrophilus** *polyclonal rabbit antiserum was positive.*

Appendix Table A-B. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh-dead 93 brood year Priest Rapids-lbnatilla fall chinook salmon during monthly juvenile fish health monitoring.

Date sampled	Raceway	Systemic Bacterial: *F. psychrophilus*	Systemic Bacterial: APS	Gill Bacteria[2]
02-94	02A	0/5 (0)	0/5 (0)	2/5 (40)
	02B	0/5 (0)	2/5 (0)	1/5 (20)
	03A	0/5 (0)	1/5 (0)	4/5 (80)
	03B	0/5 (0)	2/5 (0)	2/5 (40)
03-94	02A	0/5 (0)	1/5 (0)	0/5 (0)
	02B	1/5 (20)	4/5 (0)	1/5 (20)[3]
	03A	0/5 (0)	4/5 (0)	0/5 (0)
	03B	1/4 (25)	3/4 (0)	2/4 (50)[3]

1 *The only systemic bacteria isolated frwn kidney smear inocula were* Flexibacter psychrophilus *and aeromonad-pseudomonad (APS) types.*

2 *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made frwn gill inocula.*

3 *The rapid slide agglutination test on 2/12 of these isolates using* F. psychrophilus *polyclonal rabbit antiserum was positive.*

Appendix Table A-9. Proportions and prevalences (%) of bacterial agents isolated during monthly juvenile fish health monitoring from moribund or fresh-dead 93 brood year Carson spring chinook salmon released as subyearlings.

Date sampled	Raceway	Systemic Bacterial[1] F. *psychrophilus*	Systemic Bacterial[1] APS	Gill Bacteria[2]
12-93	O1A	0/5 (0)	1/5 (20)	5/5 (100)[3]
01-94	O1A	0/5 (0)	1/5 (0)	0/5 (0)
	O1B	0/5 (0)	4/5 (80)	ND[4]
03-94	M8A	0/5 (0)	0/5 (0)	ND[4]
	M8B	0/5 (0)	2/5 (0)	0/2 (0)
	M8C	0/5 (0)	3/5 (0)	ND[4]
04-94	M6A	0/4 (0)	0/4 (0)	1/4 (20)[3]
	M6B	0/5 (0)	1/5 (20)	2/5 (20)[3]
	M6C	1/4 (0)	2/4 (50)	2/4 (50)[3]
	M7A	0/4 (0)	1/4 (25)	0/4 (0)
	M7B	0/5 (0)	0/5 (0)	2/5 (40)[3]
	M7C	0/2 (0)	0/2 (0)	0/2 (0)

1 *The only systemic bacteria isolated from kidney smear inocula were aeromonad-pseudanonad (APS) types.*

2 *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made fran gill inocula.*

3 *The rapid slide agglutination test on 2/12 of these isolates using* F. psychrophilus *polyclonal rabbit antiserum wds positive.*

4 *Indicates not done (ND) because no moribund or fresh-dead fish were available.*

Appendix Table A-10. Proportions and prevalences (%) of bacterial agents isolated during monthly Juvenile fish health monitoring from moribund or fresh-dead 93 brood year Carson spring chinook salmon released in the fall.

Date sampled	Raceway	Systemic Bacteria: *F. psychrophilus*	Systemic Bacteria: APS	Gill Bacterial
03-94	01A	0/3	0/3	1/3
04-94	01A	0/5	0/5	0/5
05-94	01A	0/5	1/5	0/5
	01B	0/5	0/5	0/5
06-94	01A	0/5	0/5	0/5
	01B	0/5	0/5	0/5
07-94	01A	0/5	0/5	ND[2]
	01B	0/2	1/2	0/2
	M3A	0/5	1/5	0/3
	M3B	0/5	2/5	1/3
	M3C	0/5	1/5	1/2
08-94	01A	0/5	3/5	0/1
	01B	0/5	3/5	ND[2]
	02A	0/5	4/5	ND[2]
	02B	0/1	0/1	0/1
	M2A	0/3	0/3	ND2
	M2B	1/5	4/5	0/3
	M2C	0/5	5/5	0/5
	M3A	0/5	2/5	0/3
	M3B	0/3	0/3	ND[2]
	M3C	0/5	3/5	0/3

[1] *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gill inocula.*

[2] *Indicates not done (ND) because no moribund or fresh-dead fish were available.*

Appendix Table A-10. Continued.

Date sampled	Raceway	Systemic Bacteria		Gill Bacterial
		F. psychrophilus	APS	
09-94	01A	0/5	2/5	0/5
	01B	0/5	1/5	0/5
	02A	0/4	3/4	0/4
	02B	0/1	0/1	0/1
	M2A	0/5	0/5	0/5
	M2B	0/5	0/5	0/5
	M2C	0/5	0/5	0/2
	M3A	0/5	0/5	0/4
	M3B	0/5	0/5	0/5
	M3C	0/5	0/5	1/5

Appendix Table A-11. **Proportions and prevalences (%) of bacterial agents isolated during monthly juvenile fish health monitoring from moribund or fresh-dead 92 brood year Carson spring chinook juvenile salmon released in the fall.**

		Systemic Bacteria		Gill Bacterial
Date sampled	Raceway	*F. psychrophilus*	APS	
05-93	01A	0/5 (0)	0/5 (0)	1/5 (20)
06-93	03A	0/5 (0)	0/5 (0)	0/4 (0)
	03B	0/5 (0)	2/5 (40)	0/3 (0)
07-93	02A	0/5 (0)	5/5 (100)	0/1 (0)
	02B	0/5 (0)	3/5 (60)	0/2 (0)
	03A	0/2 (0)	2/2 (100)	0/1 (0)
	03B	0/5 (0)	3/5 (60)	0/3 (0)
09-93	02A	0/5 (0)	1/5 (20)	0/5 (0)
	02B	0/2 (0)	0/2 (0)	0/5 (0)
	03A	0/5 (0)	1/5 (20)	0/5 (0)
	03B	0/1 (0)	1/1 (100)	1/5 (20)
	M2A	0/5 (0)	3/5 (60)	3/5 (60)
	M2B	0/5 (0)	0/5 (0)	1/5 (20)
	M2C	0/5 (0)	0/5 (0)	5/5 (100)[2]
	M3A	0/3 (0)	0/3 (0)	1/3 (33)
	M3B	0/5 (0)	0/5 (0)	4/4 (100)
	M3C	0/3 (0)	0/3 (0)	0/3 (0)
10-93	02A	0/5 (0)	1/5 (20)	0/5 (0)
	02B	0/5 (0)	2/5 (40)	0/5 (0)
	03A	0/5 (0)	0/5 (0)	0/5 (0)
	03B	0/5 (0)	2/5 (40)	0/5 (0)
	M2A	0/5 (0)	2/5 (40)	0/5 (0)
	M2B	1/5 (20)	1/5 (20)	4/5 (80)
	M2C	1/5 (20)	0/5 (0)	5/5 (100)[2]
	M3A	0/5 (0)	2/5 (40)	0/5 (0)
	M3B	0/5 (0)	1/5 (20)	1/5 (20)
	M3C	0/5 (0)	1/5 (20)	1/5 (20)

[1] *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made frwn gill inocula.*

[2] *The rapid slide agglutination test on 2/27 of these isolates using* F. psychrophilus *polyclonal rabbit antiserum was positive.*

Appendix Table A-12. Proportions and prevalences (%) of bacterial agents isolated during monthly juvenile fish health monitoring from moribund or fresh-dead 92 brood year Carson spring chinook salmon released as yearlings.

Date Sampled	Raceway	Systemic bacterial[1] *F. psychrophilus*	Systemic bacterial[1] APS	Gill bacteria[2]
07-93	04A	0/5 (0)	1/5 (20)	0/2 (0)
08-93	04A	0/5 (0)	5/5 (100)	0/1 (0)
	04B	0/3 (0)	0/3 (0)	0/3 (0)
	05A	0/4 (0)	2/4 (50)	0/3 (0)
	05B	0/4 (0)	3/4 (75)	0/2 (0)
09-93	04A	0/2 (0)	2/2 (100)	ND[3]
	04B	0/4 (0)	3/4 (75)	0/1 (0)
	05A	0/5 (0)	3/5 (60)	0/3 (0)
	05B	0/5 (0)	2/5 (40)	0/3 (0)
10-93	04A	0/5 (0)	1/5 (20)	ND[3]
	04B	0/5 (0)	2/5 (40)	ND[3]
	05A	0/5 (0)	2/5 (40)	ND[3]
	05B	0/5 (0)	0/5 (0)	ND[3]
11-93	04A	0/5 (0)	1/5 (20)	0/4 (0)
	04B	0/5 (0)	0/5 (0)	2/2 (100)[4]
	05A	0/5 (0)	2/5 (40)	1/3 (33)
	05B	0/5 (0)	1/5 (20)	1/3 (33)
12-93	04A	0/5 (0)	4/5 (80)	0/1 (0)
	04B	0/5 (0)	4/5 (80)	1/3 (33)
	05A	0/5 (0)	3/5 (60)	0/2 (0)
	05B	0/5 (0)	1/5 (20)	3/3 (100)[4]
01-94	04A	0/5 (0)	0/5 (0)	0/3 (0)
	04B	0/5 (0)	0/5 (0)	1/1 (100)
	05A	0/5 (0)	1/5 (20)	3/3 (100)
	05B	0/5 (0)	0/5 (0)	0/3 (0)

[1] *The only systemic bacteria isolated fran kidney smear inocula were aeromonad-pseudomonad (APS) types.*

[2] *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made fran gill inocula.*

[3] *Indicates not done (ND) because no moribund or fresh-dead fish were available.*

[4] *The rapid slide agglutination test on 2/14 of these isolates using* **F. psychrophilus** *polyclonal rabbit antiserum wds positive.*

Appendix Table A-12. Continued.

Date Sampled	Raceway	Systemic bacterial		Gill bacteria[2]
		F. psychrophilus	APS	
02-94	04A	0/5 (0)	1/5 (20)	ND[3]
	04B	0/5 (0)	3/5 (60)	ND[3]
	05A	0/5 (0)	2/5 (40)	ND[3]
	05B	0/5 (0)	1/5 (20)	2/2 (100)

Appendix Table A-13. DFAT results and ELISA readings (OD_{405}) of kidney samples[1] from 93 brood year Umatilla summer steelhead juveniles sampled during monthly monitoring from two Oregon raceways (O1A and O1B) and three Michigan raceways (M5A, M5B and M5C).

	ELISA OD_{405}								
Date sampled	O1A[2]	O1A[3]	O1B[2]	O1B[3]	M5A[2]	M5A[3]	M5B[2]	M5C[2]	M5C[3]
09-93[4]	0/10	0/10							
10-93	.029		.028	.021					
	.080			.036					
	.081			.040					
	.095			.073					
	.514			.081					
11-93					.056		.071	ND5	.018
							.193		.020
									.022
									.035
									.057
12-93					008		.006	.014	.011
					016		.033	.016	.022
					043		.055	.025	.027
					047			.026	.039
					095			.032	.040
01-94					095		.448	ND[5]	.010
									.019
									.023
									.024
									.086
02-94					012		.006	.015	.006
					025		.012	.039	.008
					069		.029	.043	.025
					082		.061	.050	.152
					143				.593

[1] *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 or 1:15 weight/volume dilution for the ELISA.*
[2] *Moribund or fresh-dead fish.*
[3] *Normal, healthy appearing fish.*
[4] *Examined by the DFAT because of the small fish size.*
[5] *Not done.*

Appendix Table A-13. Continued.

Date sampled	ELISA OD_{405}								
	$O1A^2$	$O1A^3$	$O1B^2$	$O1B^3$	$M5A^2$	$M5A^3$	$M5B^2$	$M5C^2$	$M5C^3$
03-94					.007	.009			
					.010	.013			
					.013	.016			
					.032	.019			
					.104	.053			

Appendix Table A-14. Number of 93 brood year Priest Rapids-Umatilla fall chinook salmon juveniles sampled by the DFAT for *Renibacterium salmoninarum* during monthly monitoring from four Oregon raceways (O2A, O2B, 03A and O3B) in 1994.

Date sampled	Raceway					
	O2A[1]	O2B[1]	O2B[2]	O3A[1]	O3B[1]	O3B[2]
02-94	5	5	5	5	5	5
03-94	5	5	5	5	4	5

1 *Moribund or fresh-dead fish.*
2 *Normal, healthy appearing fish.*

Appendix Table A-15. DFAT results and ELISA readings (OD_{405}) for ***Renibdcterium*** *sdlmonindrum* of kidney samples[1] from 93 brood year Carson spring chinook salmon juveniles, released as subyearlings. sampled during monthly monitoring from two Oregon raceways (O1A and O1B) and nine Michigan raceways (M6A, M6B, M6C, M7A, M7B, M7C, M8A, M8B and M8C).

	DFAT				ELISA OD_{405}											
Date sampled	O1A[2]	O1A[3]	O1B[2]	0183	M6A[2]	M6B[2]	M6C[2]	M6C[3]	M7A[2]	M7B[2]	M7C[2]	M7C[3]	M8A[2]	M8B[2]	M8C[2]	M8C[3]
12-934		0/5	0/5													
01-944		1/5	0/5	0/5												
02-94													,044 .050 .055 .061 .115	,033 ,038 .044 .046 .075	.048 ,062 .079 .085 .113	.056 .062 .122 .225 .987
03-94					.029 .038 .039 .050	.021 .024 .025 .032 .075	.009 ,010 ,013 .094	.012 .014 .020 .026 .073	.014 .018 .025 .087	.013 ,015 ,016 ,023 .055	.016 .019	.007 .007 .012 .014 .015				

1 ***Individual kidney*** *samples were* ***homogenized in PBS-Tween*** 20 ***buffer at*** *a 1:15* ***weight/volume dilution for the*** *ELISA.*
2 ***Moribund or fresh-dead*** *fish.*
3 *Normal, healthy appearing* ***fish.***
4 *Examined* ***by DFAT*** because ***of*** *smdll* ***fish size.***

Appendix Table A-16. DFAT results and ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 93 brood year Carson spring chinook salmon juveniles, released in the fall, sampled during monthly monitoring from four Oregon raceways (O1A. O1B. 02A and O2B) and six Michigan raceways (M2A. M2B. M2C. M3A. M3B and M3C).

	ELISA OD_{405}														
Date sampled	01A[2]	01A[3]	01B[2]	01B[3]	02A[2]	02B[2]	02B[3]	M2A[2]	M2B[2]	M2C[2]	M2C[3]	M3A[2]	M3B[2]	M3C[2]	M3C[3]
03-94[4]	0/3	0/5													
04-94[4]	0/5	0/5													
05-94	.006		.019	.008											
	.006		.022	.014											
	.006		.024	.016											
	.009		.024	.024											
	.017		.029	.032											
06-94	,003		.011	.005											
	.007		.012	.008											
	.018		.013	.010											
	.026		.021	.011											
	,074		.025	.013											

[1] *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:15 weight/volume dilution for the ELISA.*
[2] *Moribund fresh-dead fish.*
[3] *Normal, healthy appearing fish.*
[4] *Examined by DFAT because of small fish size.*

Appendix Table A-16. Continued.

Date sampled	ELISA 00405														
	O1A[2]	O1A[3]	O1B[2]	O1B[3]	O2A[2]	O2B[2]	O2B[3]	M2A[2]	M2B[2]	M2C[2]	M2C[3]	M3A[2]	M3B[2]	M3C[2]	M3C[3]
07-94	.003		.009	006								.009	006	.009	. 009
	.010		.017	010								,014	013	.011	.009
	,011		,025	019								.022	013	.018	.012
	,012		,027	024								.039	022	.024	,023
	.017		.330	030								.128	050	.030	,073
08-94	.007		,023	012	012	.008	004	,017	,015	1.823	.009	.014	010	.044	.005
	.019		,024	013	013	.015	018	,026	.016	2.478	.012	.018	070	2.291	.013
	.020		.031	017	033		020	,996	.016	2.517	.014	.045		2.411	.024
	.040		.106	033	060		062		.020	2.575	.016	.050		2.583	.025
	,093		2.663	038	089		074		.026	2.626	.024	.081		2.584	2.583
09-94	.018		.014	017	032	,092	010	.011	.050	,016	.009	,044	044	.023	.028
	,020		.028	019	044		011	,051	,058	1.004	.011	.050	038	.044	.036
	.022		.049	030	049		017	,060	,105	2.481	.015	.090	075	1.171	.036
	.032		,063	134	096		021	,064	.113	2.546	.017	.215	279	2.692	,052
	.696		.351	248			052	.094	.151	2.786	.306	.244	535	2.851	.071

Appendix Table A-17. ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 92 brood year Carson spring chinook salmon juveniles, released in the fall, sampled during monthly monitoring from Oregon raceways O1, O2, and O3 (O1A, O2A, O2B, O3A and O3B) and Michigan raceways M2 and M3 (M2A, M2B, M2C, M3A, M3B and M3C).

	ELISA OD_{405}															
Date sampled	O1A[2]	O1A[3]	O2A[2]	0282	0283	O3A[2]	0382	0383	M2A[2]	M2B[2]	M2C[2]	M2C[3]	M3A[2]	M3B[2]	M3C[2]	M3C[3]
05-93[4]	1/5	0/5														
06-93							.009	.008	.004							
							.011	,010	.004							
							.028	.011	.006							
							2.754	.142	.007							
							3.007	3.004	.008							
07-93			.061	.033	.004	.051	.070	.002								
			.075	.068	.005	2.961	.276	.003								
			.715	.206	.006		.306	.010								
			2.558	2.610	,007		2.720	.012								
			2.680	3.081	.008		3.008	,019								

[1] *Individual kidney samples were hwnogenized in PBS-Tween 20 buffer at a 1:15 weight/volume dilution for the ELISA.*
[2] *Moribund fresh-dead fish.*
[3] *Normal, healthy appearing fish.*
[4] *Examined by DFAT because of small fish size.*

Appendix Table A-17. Continued.

Date sampled	ELISA OD_{405}															
	O1A[2]	O1A[3]	O2A[2]	0282	O2B[3]	O3A[2]	O3B[2]	0383	M2A[2]	M2B[2]	M2C[2]	M2C[3]	M3A[2]	M3B[2]	M3C[2]	M3C[3]
09-93			2 368	.424	117	.271	2 446	441	813	2.386	163	.006	1.598	.471	1.098	.047
			2 516	.484	135	.333	2 449	585	2 330	2.630	477	.070	2.650	2.383	2.560	.068
			2 538	2.589	324	.346	2 542	638	2 371	2.738	576	.109	2.716	2.586	2.600	.246
			2 573	2.613	331	2.422	2 573	655	2 427	2.801	1 029	.243	2.634	.458		
			2 635	2.748	511	2.428	2 773	1 037	2 513	2.862	2 435	2.515				.466
10-93			080	.057	057	.234	211	268	034	.338	473	.069	.124	.509	.266	.264
			089	.057	059	.264	1 753	425	457	.950	1 039	.114	.196	.649	1.766	.408
			216	.160	066	,525	2 147	552	722	2.181	1 548	.173	.265	2.243	2.078	,529
			2 160	2.306	407	,870	2 360	776	2 112	2.494	2 133	.430	2.109	2.493	2.166	.553
			2 594	2.478	449	,976	2 416	960	2 393	2.554	2 513	,778	2.438	2.675	2.187	1.067

Appendix Table A-18. ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 92 brood year Carson spring chinook salmon juveniles. released as yearlings. sampled during monthly monitoring from four Oregon raceways (04A. 04B. 05A and 05B).

	ELISA OD_{405}						
Date sampled	04A[2]	04A[3]	0482	04B[3]	05A[2]	05B[2]	05B[3]
07-93	.009	.002					
	.010	.003					
	.015	.004					
	.032	.004					
	.342	.007					
08-93	.021		.006	.009	.007	.010	.004
	.044		.010	.010	.017	.012	.006
	.054		.045	.011	1/2[4]	·052	.009
	0/2[4]			.013		0/1[4]	·009
				.014			.010
09-93	.047		.052	.023	.043	.613	.155
	.055		.057	.036	.064	2.305	.290
			,458	.043	2.246	2.375	.477
			2.517	.466	2.411	2.432	.479
				2.075	2.439	2.484	.556
10-93	.087		2.358	.107	2.220	2.261	.021
	2.415		2.363	.122	2.331	2.263	.021
	2.493		2.387	.157	2.382	2.392	.030
	2.495		2.482	,248	2.487	2.434	.109
	2.519		2.537	,270	2.499	2.456	.555
11-93	.018		.033	.088	.170	.060	.024
	.032		.215	.131	.930	.068	.044
	.045		.422	.215	1.586	.111	.051
	2.370		1.693	,442	2.501	.324	.491
	2.451		2.462	,468	2.602	2.610	.654

[1] *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution for the ELISA.* *1:15*

[2] *Moribund or fresh-dead fish.*

[3] *Normal. healthy appearing fish.*

[4] *Examined by DFAT because of small fish size.*

Appendix Table A-18. Continued.

Date sampled	ELISA OD_{405}						
	04A[2]	04A[3]	04B[2]	04B[3]	05A[2]	05B[2]	05B[3]
12-93	.023		.315	.079	.104	.342	086
	1.135		.548	.317	.209	.549	145
	2.105		.615	.384	2.184	.631	325
	2.157		2.316	.409	2.302	2.324	533
	2.435		2.331	.459	2.484	2.440	544
01-94	,021		.019	.013	.014	.519	017
	.023		.028	.020	.019	1.366	021
	.613		.034	.029	.125	1.659	041
	2.042		2.093	.054	.788	2.612	043
	2.364		2.164	.590	2.449	2.681	082
02-94	.034		.007	.036	1.088	.076	037
	.036		.050	.071	1.504	.128	044
	.052		.083	.074	2.121	.302	107
	.145		2.723	.107	2.170	,759	329
	2.815		2.826	.224	2.851	2.828	602

Appendix Table A-19. Preliberation ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 30 Umatilla 93 brood year summer steelhead juveniles from each of three Michigan raceways (M5A, M5B and M5C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish in M5B and M5C were sampled on 3-15-94 at mean body weights of 78.3 and 79.7 gms/fish, respectively. M5A was sampled on 4-6-93 at 74.0 gms/fish.

Sample number	ELISA OD_{405} M5A	M5B	M5C
01	.009	.004	.001
02	.010	.004	.001
03	.011	.005	.002
04	.012	.005	.002
05	.012	.006	.002
06	.012	.006	.003
07	.012	.006	.003
08	.012	.007	.003
09	.016	.007	.005
10	.016	.008	.006
11	.017	.009	.006
12	.017	.009	.006
13	.018	.011	.007
14	.018	.011	.007
15	.019	.012	.008
16	.020	.012	.008
17	.022	.013	.008
18	.023	.014	.010
19	.025	.014	.010
20	.026	.017	.013
21	.028	.017	.013
22	.033	.019	.013
23	.035	.020	.013
24	.037	.029	.013
25	.037	.030	.014
26	.050	.031	.018
27	.053	.036	.027
28	.060	.042	.042
29	.079	.069	.093
30	.107	.104	.454
Mean	.028	.019	.027
Range	.009-.107	.004-.104	.001-.454

[1] *Individual kidney samples were hanogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution.*

Appendix Table A-20. Preliberation ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 30 Priest Rapids-Llmatilla 93 brood year fall chinook salmon juveniles from each of four Oregon raceways (02A, 02B, 03A and 03B) and six Michigan raceways (M2A, M2B, M2C, M3A, M3B and M3C) Means and ranges for each raceway are shown below the 30 individual sample readings. Fish in four Oregon and six Michigan were sampled on 5-5-94 at a mean body weight of 5.34 gms/fish.

	ELISA OD_{405}									
Sample number	02A	028	03A	03B	M2A	M2B	M2C	M3A	M3B	M3C
01	.004	.014	.009	.003	.009	.014	.013	.007	.003	.022
02	.008	.016	.028	.010	.015	.015	.015	.008	.003	.023
03	.009	.016	.029	.011	.019	.018	.015	.009	.004	.025
04	.011	.018	.030	.018	.021	.020	.017	.010	.005	.026
05	,012	.021	.030	,018	.022	.031	.017	.013	.006	.027
06	.012	.026	,032	,025	.024	.031	.022	.013	.006	.029
07	.016	.029	.033	.026	.024	.033	.022	.013	.007	.032
08	.017	.031	.033	.026	.024	.033	.023	.016	.008	.032
09	.017	.033	.036	.027	.026	.033	.023	.017	.008	.033
10	.017	.034	.038	.027	.026	.033	.025	.017	.008	.034
11	.018	.035	.040	.027	.028	.035	.026	.017	.009	.035
12	.019	.037	,041	.029	.028	.035	.029	.019	.009	.043
13	.019	.040	.041	.030	.030	.036	.032	.020	.010	.043
14	.019	.040	.045	.030	.032	.036	.035	.021	.010	.045
15	.021	.040	.045	.031	.034	.038	,042	.021	.011	.045
16	.021	.041	.046	.032	.034	.040	.046	.022	.012	.046
17	.022	.043	.055	.034	.040	.040	.051	.023	.014	.051
18	.022	.044	.058	.034	.040	.045	.058	.023	.015	.052
19	.024	.044	.058	.034	.041	.046	.066	.023	.016	.053
20	.025	.046	.060	.037	.041	.046	,069	.025	.016	.054
21	.025	.048	.060	.037	.042	.048	.071	.025	.016	.055
22	.026	.049	.061	.039	.043	.052	.071	.025	.020	.055
23	.026	.054	.063	.040	.045	.058	.076	.032	.026	.056
24	.029	.056	.082	.044	.047	.059	.081	.033	.027	.061
25	.031	.059	.086	,046	.047	.068	.084	.034	.028	.066
26	.031	.064	.102	.047	.048	.071	.104	.037	.033	.089
27	.034	.065	.103	.050	.050	.079	.119	.038	.036	.097
28	.042	.071	.104	.053	.053	.080	.129	.046	.036	.097
29	.044	.072	.185	.054	.056	.124	.133	.073	.039	.108
30	.049	.091	.397	.077	.094	.215	.177	.233	.135	.193
Mean	.022	.043	.068	.003	,036	.050	.056	.030	.019	.054
Range	004-.049	.014-.091	.009-.397	.030-.077	.009-.094	.014-.215	.013-.177	.007-.233	.003-.135	.022-.193

[1] *Individual kidney samples were homogenized in PBS-Tween 20 buffer at 1:15 weight/volume dilution.*

Appendix Table A-21. Preliberation ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 30 Carson 93 brood year spring chinook salmon juveniles. released as subyearlings. from each of six Michigan raceways (M6A. M6B. M6C. M7A. M7B and M7C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish were sampled on 4-27-94 at a mean body weight of 13.8 gms/fish.

Sample number	ELISA 00405 M6A	M6B	M6C	M7A	M7B	M7C
01	.016	.015	.015	.023	.007	.015
02	.016	.019	,017	.025	.012	.018
03	.017	.019	.017	.025	.012	.021
04	.017	.020	.018	.027	.015	.022
05	.017	.022	.018	.028	.015	.023
06	.018	,023	.018	.030	.016	.023
07	.019	.023	.019	.030	.016	.024
08	.020	.024	.019	.030	.017	.024
09	.020	.025	.020	.030	.017	.025
10	.027	,025	.020	.031	.017	.025
11	.027	.026	.021	.031	.018	.027
12	.027	.027	.021	.032	.018	.027
13	.027	.028	.022	.032	.020	.028
14	.027	.028	.023	.033	.022	.030
15	.028	.028	.023	.033	.022	.031
16	.029	.029	.024	.038	.022	.031
17	.030	.030	.024	.039	.023	.032
18	.034	.030	.026	.039	.024	.032
19	.034	.030	.026	.039	.026	.032
20	.034	.031	.026	.040	.028	.033
21	.036	.033	.027	.041	.029	.033
22	.037	,033	.027	.046	.029	.033
23	.039	.033	.027	.049	.032	.037
24	.039	.035	.027	.051	.033	.038
25	.039	.036	.028	.051	.034	.038
26	.041	.043	.030	.053	.039	.047
27	.041	.049	.033	.078	.045	.056
28	.042	.056	.035	.079	.058	.060
29	.053	.077	.035	.083	.117	.101
30	.054	.092	.044	.097	.239	.220
Mean	.030	.033	.024	.042	.034	.040
Range	.016-.054	.015-.092	.015-.044	.023-.097	.007-.239	.015-.220

1 *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution.*

Appendix Table A-22. Preliberation ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 30 Carson 93 brood year spring chinook salmon juveniles. released in the fall. from each of four Oregon raceways (O1A. O1B. O2A and O2B) and six Michigan raceways (M2A. M2B. M2C. M3A. M3B and M3C). Means and ranges for each raceway are shown below the 60 individual sample readings. Fish in four Oregon and six Michigan raceways were sampled on 10-18-94 at mean body weights of 21.4 gms/fish and 25.8 gms/fish. respectively.

	ELISA OD_{405}									
Sample number	O1A	O1B	O2A	O2B	M2A	M2B	M2C	M3A	M3B	M3C
01	.009	009	007	.011	.005	.010	,006	005	004	009
02	.012	013	008	.016	.009	.011	.010	007	007	010
03	.012	015	009	.017	.010	.012	.011	009	008	011
04	.013	019	009	.017	.012	.015	.012	010	011	013
05	.016	023	010	.019	.018	.015	.013	011	012	013
06	,017	023	011	.022	.022	.015	.015	011	012	013
07	.017	023	011	.023	.023	.016	.015	013	013	015
08.	.019	024	012	,027	.031	.017	.017	014	013	017
09	.022	025	012	.029	.031	.017	.017	015	013	018
10	.024	029	012	.030	.036	.018	.018	016	014	019
11	.028	.029	.012	031	.039	.019	.018	016	015	020
12	.028	.030	.013	032	.039	.019	.019	016	016	021
13	.029	.030	.013	035	.039	.019	.021	016	016	022
14	.030	.031	.013	035	.041	.020	.022	019	016	024
15	.035	.033	.014	035	.043	.022	,023	020	016	024
16	.039	.034	.015	043	.044	.023	024	022	018	024
17	.039	.038	016	049	.046	,023	.025	022	019	025
18	.040	.039	016	050	.049	.025	.027	022	020	026
19	.042	.041	.019	054	.061	.025	.029	024	022	030
20	.052	.045	.020	055	.061	.026	.034	025	024	031
21	.045	.045	.021	.056	.066	,027	.036	.026	026	031
22	.045	.051	.025	,058	.068	.027	.043	.026	027	031
23	.046	.052	.026	.059	.069	.029	,051	.028	028	032
24	.049	.057	028	.061	.070	.030	.052	.029	.029	.032

1 *Individual kidney samples were hwnogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution.*

Appendix Table A-22. Continued.

Sample number	ELISA OD_{405}									
	O1A	O1B	O2A	O2B	M2A	M2B	M2C	M3A	M3B	M3C
25	.051	058	031	063	.076	.032	.052	.035	.029	.035
26	.060	059	031	065	,085	.042	.054	.037	.031	.035
27	.061	059	033	068	.085	.042	.055	.038	.032	.050
28	.062	079	038	071	.118	.044	.065	.039	.037	.053
29	.077	080	039	081	.137	.049	.088	.056	.040	.062
30	.101	083	074	115	.157	.073	.148	.060	.047	.087
Mean	.037	.039	.020	.044	.053	.025	.034	.023	.021	.028
Range	.009-	.009-	.007-	.011-	.005-	.010-	.006-	.005-	.004-	.009-
	.101	.083	.074	.115	.157	.073	.148	.060	.047	.087

Appendix Table A-23. Preliberation ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 60 Carson 92 brood year spring chinook salmon juveniles. released in the fall. from each of four Oregon raceways (O2A. O2B. O3A and O3B) and six Michigan raceways (M2A. M2B. M2C. M3A. M3B and M3C). Means and ranges for each raceway are shown below the 60 individual sample readings. Fish in four Oregon and six Michigan raceways were sampled on 11-01-93 at mean body weights of 23.3 gms/fish and 25.6 gms/fish. respectively.

Sample number	ELISA OD_{405} O2A	O2B	O3A	O3B	M2A	M2B	M2C	M3A	M3B	M3C
01	.013	.011	.014	.022	.022	.025	.015	.018	.018	.018
02	.014	.014	.025	.024	.025	.032	.022	.026	.023	.020
03	.016	.018	.027	.029	.026	.039	.022	.028	.024	.033
04	.022	.019	.027	.031	,027	.039	.025	.030	.031	.034
05	.023	.020	.028	.035	.033	.043	.033	.035	.036	.036
06	.023	.021	.028	.035	.034	.044	.034	.036	.039	.037
07	.025	.021	.031	,036	.039	.047	.039	.038	.040	.038
08	,027	.027	.032	.040	.040	.048	.043	.038	.040	.039
09	.028	.028	.033	.044	.040	.050	.045	.048	.040	.040
10	.031	.028	.033	.047	,046	.051	.046	.049	.040	.043
11	.033	.031	.034	.047	.047	.053	.047	.053	.042	.046
12	.033	.031	.035	.049	.047	.056	.049	.053	.054	.049
13	.035	.032	.037	.054	.047	.058	.051	.054	.056	.050
14	.035	.034	.038	.054	.048	.061	.052	.061	.058	.051
15	.040	.036	,038	.054	.049	.066	.052	.068	.062	.051
16	.041	.037	.039	.056	,058	.077	.052	.071	.063	.052
17	,042	.039	.042	.058	.058	.082	.055	.075	.064	.053
18	.042	.040	.043	.060	.059	.083	.061	.076	.064	.055
19	.044	.040	.043	.070	,062	.096	.067	.080	.072	.055
20	.045	,042	.045	.071	.066	.100	.068	.081	.072	.058
21	.056	.045	.045	.072	.067	.103	.070	.081	.074	.060
22	.059	.049	.047	.073	.068	.110	.073	.082	.075	.061
23	.060	.050	.048	.078	.069	.112	.074	.086	.078	.061
24	.064	.051	.050	.079	.074	.113	.081	.087	.087	.070
25	,064	.051	.053	.079	.074	.118	.087	.092	.092	.072
26	.066	.052	.054	,083	.074	.120	.088	.093	.096	.082
27	.067	.053	.056	.094	.074	.127	.090	.095	.101	.093
28	,069	.054	.056	.100	.076	.128	.093	.096	.103	.095
29	.070	.055	.059	.106	.076	.135	,096	.104	.108	.097
30	.071	.055	.059	.107	.080	.143	.096	.104	.116	.107

1 *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution.*

Appendix Table A-23. Continued.

Sample number	ELISA 00405 02A	02B	03A	03B	M2A	M2B	M2C	M3A	M3B	M3C
31	.073	.057	.065	.111	.083	.149	.097	.109	.117	.115
32	.079	.057	.067	.111	.093	.157	.099	.127	.125	.124
33	.081	.057	,072	.115	.097	.167	.101	.129	.139	.131
34	.085	.060	.079	.116	.104	.171	.103	.135	.169	.137
35	.086	.062	.083	.123	.112	.172	.104	.139	,172	.140
36	.091	.063	.085	.148	.116	.178	.114	.139	.176	.152
37	.093	.063	.088	.152	.120	.209	.116	.149	.187	.163
38	.096	.070	.108	.162	.121	.213	.124	.152	.188	.165
39	.096	.077	.110	.164	.124	.223	.141	.157	.190	.182
40	.099	.083	.112	.197	.129	.238	.159	.160	.198	.185
41	.101	.084	.126	.200	.132	.242	.167	.173	.210	.194
42	.104	.089	.139	.200	.137	.277	.179	.177	.216	.237
43	.107	.095	.146	.202	.147	.304	.182	.178	.217	.329
44	.107	.100	.149	.205	.158	.323	.186	.200	.241	.331
45	.109	.102	.162	.221	.175	.346	.212	.207	,248	.354
46	.112	.104	.170	.237	.179	.363	.218	.213	,274	.363
47	.113	.106	.196	.252	.185	.401	.233	.215	.317	.370
48	.122	.108	.203	.285	,257	.445	.262	.231	.336	.490
49	.138	.111	.230	.310	.269	.521	.400	.356	.478	.633
50	.141	.114	.285	.352	.287	.651	.418	.375	.510	.683
51	.142	.148	.307	.418	.360	.694	.418	.404	.573	.669
52	.149	.161	.353	.463	.383	.754	.421	.465	.577	.767
53	.155	.161	.407	.565	.399	.819	.533	.591	.635	.915
54	.218	.238	.460	.569	.447	.943	.548	.684	.718	.955
55	.313	.239	.526	.641	.485	.951	.607	.725	.908	.999
56	.492	.357	1.049	.698	.583	.978	.751	.745	1.037	1.002
57	.653	.365	1.322	.777	.674	1.013	.778	.865	1.593	1.022
58	.736	.376	2.056	.791	.904	1.045	1.140	.950	1.778	2.009
59	1.983	.418	2.343	1.142	1.241	1.048	1.409	1.391	2.115	2.204
60	2.127	.526	2.354	1.327	1.878	1.087	1.435	2.462	2.137	2.308
Mean	.171	.096	.251	.218	.186	.291	.223	.249	.311	.334
Range	.013-2.127	.011-.526	.014-2.354	.022-1.327	.022-1.878	.025-1.087	.015-1.435	.018-2.462	.018-2.137	.018-2.308

Appendix Table A-24. Preliberation ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from two 30-fish sample groups of 92 brood year Carson spring chinook salmon juveniles. released in the fall. from each of four Oregon raceways (O2A. O2B. O3A and O3B) and six Michigan raceways (M2A. M2B. M2C. M3A. M3B and M3C). Fish in the sample groups numbered 1-30 were bled when sacrificed and the kidneys were removed from the fresh carcasses. Fish in the sample groups numbered 31-60 were not bled and the fish were frozen prior to removing the kidneys. Means and ranges for each 30-fish group are shown below the individual sample readings. Fish from the four Oregon and six Michigan raceways were sampled on 11-01-93 at mean body weights of 23.3 gms/fish and 25.6 gms/fish. respectively.

ELISA OD_{405}

07A		O2B		03A		03B	
1-30	31-60	1-30	31-60	1-30	31-60	1-30	31-60
.023	,013	.028	.011	.014	.027	.022	.029
.027	.014	.028	.014	.025	.028	.024	.035
.033	.016	.031	.018	.027	.032	.031	.035
.059	.022	.032	.019	.028	.033	.044	.036
.067	,023	.036	.020	.031	.033	.047	.040
.069	.025	.045	.021	.034	.035	.054	.047
.070	.028	.050	.021	.038	.037	,058	.049
.071	.031	.051	.027	.042	.038	.073	.054
.073	.033	.053	.031	.053	.039	,083	.054
.081	.035	.055	.034	.065	.043	.094	.056
.086	.035	.055	.037	.072	.043	.107	.060
.091	.040	.057	.039	.079	.045	.115	.070
.093	.041	,063	.040	.083	.045	123	.071
.096	.042	.070	.040	.085	.047	.148	.072
.099	.042	.077	042	.088	,048	.152	.078
.109	.044	.084	.049	.112	.050	,162	.079
.112	.045	.089	.051	.126	.054	.200	.079
.113	.056	.095	.052	.139	056	.202	.100
.122	.060	.100	.054	.146	.056	.205	.106
.138	.064	.102	.057	.149	.059	.237	.111
.141	.064	.104	.057	.170	.059	.285	.111
.142	.066	.106	.060	.203	067	.310	.116
.149	.079	.108	062	.230	.108	.352	.164
.155	.085	.110	063	,285	.110	.463	.197
.218	.096	.161	.083	.353	162	565	.200
.313	.101	.239	.144	.460	196	.569	.221
,492	.104	.357	.148	.526	.307	.641	.252
.653	.107	.365	.161	1.049	.407	.777	.418
.736	.107	.376	.238	1.322	2.056	1.142	.698
2.127	1.983	.418	.562	2.343	2.354	1.327	.791
Mean							
225	.117	.118	.073	.279	.222	.287	.148
Range							
.023- 2.127	.013- 1.983	.028- .418	.011- .562	.014- 2.343	.027- 2.354	.022- 1.327	.029- .791

Appendix Table A-24. Continued.

ELISA OD_{405}

M2A		M2B		M2C		M3A		M38		M3C	
1-30	31-60	1-30	31-60	1-30	31-60	1-30	31-60	1-30	31-60	1-30	31-60
.025	.022	.044	.025	.022	.015	.076	.018	.023	.018	.040	.018
.034	.026	.083	,032	.022	.043	.081	.026	.024	.031	.046	.020
,040	.027	.096	.039	.025	.045	.081	.028	.036	.039	.049	.033
.047	.033	.103	.039	.033	.046	.086	.030	.040	,040	.051	.034
.048	.039	.110	,043	.034	,047	.087	.035	.040	,040	.055	.036
.049	.040	.113	,047	.039	,051	.092	.036	.054	.042	.058	.037
.059	.046	.118	.048	.049	.052	.095	,038	.056	.058	.060	.038
.062	,047	.120	.050	.052	.052	.104	.038	.062	.064	.061	.039
.067	.047	.127	.051	.055	.073	.104	.048	.063	.072	.061	.043
.068	.058	.128	.053	.061	.074	.109	,049	.064	.072	.070	.050
.069	.058	.143	.056	,067	.081	.127	.053	.087	.074	.082	.051
.074	,066	.167	.058	.068	.087	.139	.053	.092	.075	.093	.052
.074	.074	.178	.061	.070	,088	.139	.054	.096	.078	.107	.053
.074	.076	.209	.066	.090	,096	.149	.061	.108	.101	.115	.055
.080	.076	.213	.077	.093	.097	.152	.068	.169	.103	.137	.072
.083	.093	.238	.082	.096	.099	.157	.071	.187	.116	.140	.095
.097	.116	.242	.100	.141	.101	.160	.075	.188	.117	.152	.097
.104	.124	.277	.112	.179	.103	.173	.080	.190	.125	.163	.124
.112	.129	.304	.135	.218	.104	.177	.082	.198	,139	.165	.131
.120	.147	.363	.149	.233	.114	.178	.093	.241	.172	.185	.182
,121	.158	.401	.157	.400	.116	.200	.096	.274	.176	.329	.194
.132	.175	.445	.171	.418	.124	.207	.129	,317	.210	.354	.237
.137	.179	.521	.172	.533	.159	.231	.135	.336	.216	.363	.331
.287	.185	.651	.223	.548	.167	.356	.213	.510	.217	.490	.370
.383	.257	.694	.323	.607	.182	.375	.215	,573	.248	.633	.683
.399	.269	.754	.346	.751	.186	.465	.404	.577	.478	.767	.699
.485	.360	.819	.943	.778	.212	.591	.684	.635	.718	.915	.999
.583	.447	1.013	.951	1.140	.262	.725	.745	1.037	.908	.955	1.002
.904	.674	1.048	.978	1.409	.418	.950	.865	1.593	1.778	2.009	1.022
1.878	1.241	1.087	1.045	1.435	.421	1.391	2.462	2.115	2.137	2.204	2.308
Mean											
.223	.176	.360	.221	.322	.124	.265	.233	.333	.289	.364	.304
Range											
.025-1.878	.022-1.241	.044-1.087	.025-1.045	.022-1.435	.015-.421	.076-1.391	.018-2.462	.023-2.115	.018-2.137	.040-2.204	.018-2.308

Appendix Table A-25. Preliberation ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 30 Carson 92 brood year spring chinook salmon Juveniles. released as yearlings. from each of four Oregon raceways (04A. 04B. 05A and 05B). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish were sampled on 3-15-94 at a mean body weight of 53.4 gmsifish.

Sample number	ELISA OD_{405} 04A	04B	05A	05B
01	.010	.014	.012	.007
02	.011	.019	.012	.008
03	.011	.019	.012	.008
04	.011	.022	.016	.011
05	.012	.026	.019	.011
06	,012	.027	.023	,011
07	.013	,027	.024	,011
08	.014	.029	.025	.011
09	.014	.030	.026	.012
10	.015	.031	.028	.012
11	.018	.032	.030	.015
12	.019	.035	.031	.016
13	.023	.037	.034	.017
14	.024	.040	.035	.018
15	.026	.041	,038	.019
16	.027	.042	.044	.020
17	.030	.042	.046	.023
18	.030	.042	.047	.026
19	.030	.046	.053	.027
20	.034	.047	.057	.028
21	.034	.051	.058	.032
22	.044	,052	.061	.033
23	.044	.061	.067	.033
24	,046	.066	.074	.035
25	.059	.076	.087	.035
26	.069	,116	.114	.035
27	.090	.148	.120	.040
28	,212	.188	.155	.042
29	.265	.359	.171	.045
30	1.356	.867	.501	.130
Mean	.087	.088	.067	.026
Range	.010-1.356	014-.867	.012-.501	.007-.130

1 *Individual* ***kidney samples were*** *homogenized in* **PBS-Tween** *20 buffer* ***at a*** *1:7 weight/volume dilution.*

Appendix Table A-26. Preliberation ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 60 Carson 92 brood year spring chinook salmon juveniles. released as yearlings. from eight raceways (B1. B2. B3. B4. B5. B6. B7 and B8) at Bonneville Hatchery. Means and ranges for each raceway are shown below the individual sample readings. Fish were sampled on 3-02-94 at a mean body weight of 37.8 gms/fish.

	ELISA OD_{405}							
Sample number	B1	B2	B3	B4	B5	B6	B7	B8
01	022	.026	.013	031	028	.021	025	.038
02	037	.028	.029	033	040	.027	046	.112
03	039	.031	.040	036	040	.029	056	.154
04	050	.035	.041	039	041	.031	059	.217
05	051	.036	.044	047	046	.031	071	
06	061	.051	.049	056	060	.033	078	
07	070	.053	.058	059	063	.057	112	
08	077	.090	.062	114	084	.082	114	
Mean	.051	.044	,042	.052	.050	.039	.070	.130
Range	.022-.077	.026-.090	.013-.062	.031-.114	.028-.084	.021-.082	.025-.114	.038-.217

[1] *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution.*

Appendix Table A-27. ELISA readings (OD_{405}) for *Renibacterim salmoninarwn* of kidney samples[1] from 71 Umatilla summer steelhead adults spawned in 1994 for Umatilla Hatchery 94 brood year production.

Sample number	ELISA OD_{405}	Sample number	ELISA OD_{405}	Sample number	ELISA OD_{405}
1	.004	26	.017	51	.029
2	.005	27	.017	52	.031
3	.006	28	.017	53	.033
4	.007	29	.017	54	.033
5	.007	30	.017	55	.034
6	.008	31	,018	56	.034
7	.009	32	.018	57	.036
8	.009	33	.019	58	.039
9	,010	34	.019	59	.039
10	.011	35	.019	60	.040
11	.011	36	.019	61	.042
12	.012	37	.020	62	.046
13	.012	38	.020	63	.053
14	,013	39	.020	64	,060
15	.013	40	.020	65	.064
16	.014	41	.020	66	.064
17	.014	42	.020	67	.077
18	.014	43	.022	68	.137
19	.014	44	.022	69	.409
20	.015	45	.022	70	.480
21	.015	46	.023	71	1.348
22	.015	47	.025		
23	.016	48	.026		
24	,016	49	.027		
25	.016	50	.029		

[1] *Individual kidney samples were hcnnogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.*

Appendix Table A-28. ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of kidney samples[1] from 16 Umatilla summer steelhead adult mortalities in 1994.

Sample number	ELISA OD_{405}	Sample number	ELISA OD_{405}
1	006	9	035
2	020	10	036
3	022	11	038
4	022	12	040
5	022	13	045
6	025	14	045
7	027	15	045
8	031	16	056

1 *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.*

Appendix Table A-29. Date and number of spawned adults sampled for culturable viruses from Priest Rapids fall chinook salmon spawned in 1993 for Umatilla Hatchery 93 brood year production. Culturable viruses were sampled for as individual ovarian fluids (OF) from females.

	Number and type of sample for culturable viruses
Date sampled	OF
11-08-93	60
11-15-93	60

Appendix Table A-30. ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of 60 kidney samples[1] from Priest Rapids fall chinook salmon adults spawned in 1993 for Umatilla Hatchery 93 brood year production.

Date sampled	ELISA DD405	Date sampled	ELISA OD_{405}
11-8-93	.011	11-15-93	.012
	.012		,012
	.012		.012
	.013		.013
	.014		.013
	.014		.013
	.016		.014
	.016		.014
	.016		.016
	.017		.017
	.017		.017
	.018		.018
	.018		.019
	,018		.019
	,018		.019
	.019		.022
	.021		.022
	.022		.024
	.022		.025
	.022		.025
	.023		.028
	.028		.029
	.032		.034
	.033		.036
	.035		.052
	.040		.052
	.041		.056
	.044		.071
	.046		.078
	.084		.098
Mean	.025		.029
Range	.011-.084		.012-.098

[1] *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.*

Appendix Table A-31. Date and number of adults sampled for erythrocytic inclusion body syndrome (EIBS) and culturable viruses from Umatilla fall chinook salmon spawned at Minthorn Ponds in 1993 for Umatilla Hatchery 93 brood year production. Culturable viruses were sampled for as individual ovarian fluids (OF) from females or individual milts (M) from males. and two-fish pyloric caeca/kidney/spleen (PKS) pools from two females.

Date sampled	Number Sampled for EIBS	Number and type of sample for culturable viruses		
		OF	M	PKS
11-04-93	60	38	38	14
11-08-93	36	18	18	9
11-10-93	14	7	7	2
11-16-93	36	18	18	0
11-23-93	12	6	6	0

Appendix Table A-32. ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of 174 kidney samples[1] from Umatilla fall chinook salmon adults spawned at Minthorn Ponds in 1993 for Umatilla Hatchery 93 brood year production.

	ELISA OD_{405}			ELISA OD_{405}			ELISA OD_{405}	
Date sampled	Female	Male	Date sampled	Female	Male	Date sampled	Female	Male
11-04-93	,010	.011	11-08-93	.014	,013	11-16-93	.015	.008
	.010	.014		.014	,013		.015	.012
	.010	.015		,016	.019		.016	.012
	.011	.016		.017	.021		.019	.018
	.012	.017		.018	.022		.020	.018
	.013	.017		.019	.025		.022	.020
	.013	.019		.021	.026		.026	.020
	.013	.023		.022	.029		.031	.023
	.013	,024		.023	.036		.032	.024
	.014	.025		.026	.040		.035	.029
	.014	.026		.038	.043		.038	.031
	.015	.027		.040	.048		.050	.057
	.015	.029		.043	.051		.054	.066
	.015	.030		.044	.060		.056	.076
	.015	.031		.049	.060		.077	.080
	.016	.033		.053	.086		.080	.081
	.016	.034		.079	.101		.085	.114
	.016	.034		.107	.122		.232	.129
	.017	.040						
	.017	.042	11-10-93	.010	.011	11-23-93	.022	.012
	.017	.042		.015	.012		.025	.015
	.017	.055		.015	.013		.025	,018
	.018	.070		.022	.023		.030	.034
	,018	.086		.028	.033		.034	.039
	.018	.093		.028	.038		.052	.105
	.019	.109		.049	.043			
	.019	.110						
	.019	.112						
	.020	.114						
	.021	.120						
	.021	.176						
	.022	.182						
	.022	.190						
	.024	.193						
	.026	.209						
	.036	.268						
	.037	.322						
	.056	.371						

[1] *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.*

Appendix Table A-33. Proportions and prevalences of erythrocytic inclusion body syndrome (EIBS) detected in blood smears collected from Bonneville fall chinook salmon spawned in 1993 for Bonneville Hatchery 93 brood year production.

Date sampled	Proportion and prevalence (%) of EIBS	
	Male	Female
11-01-93	0/15 (0%)	15[1]
11-08-93	0/15 (0%)	0/15 (0%)
11-15-93	3/15 (20%)	0/15 (0%)
11-22-93	3/15 (20%)	0/15 (0%)
12-02-93	2/15 (13%)	0/15 (0%)
Totals	8/75 (11%)	0/60 (0%)

[1] *These 15 blood smears were not readable because of water on the slides*

Appendix Table A-34. Proportions and prevalences of infectious hematopoietic necrosis virus (IHNV) detected in ovarian fluid[1] and pyloric caeca/kidney/spleen (PKS[2]) samples collected from Bonneville fall chinook salmon spawned in 1993 for Bonneville Hatchery 93 brood year production.

Date sampled	Proportion and prevalence (%) of IHNV	
	Ovarian fluid	PKS
11-01-93	0/20 (0%)	0/12 (0%)
11-04-93	3/56 (5%)	ND
11-08-93	0/48 (0%)	ND
11-10-93	0/39 (0%)	ND
11-15-93	8/48 (17%)	ND
11-18-93	0/48 (0%)	ND
11-22-93	16/48 (33%)	ND
11-24-93	0/31 (0%)	ND
12-02-93	19/48 (40%)	ND
12-09-93	22/23 (96%)	ND

[1] *Ovarian fluids were three-female pooled samples.*
[2] *PKS samples were from five-female pooled samples.*

Appendix Table A-35[1]. Distribution of ELISA (OD_{405}) values, by OD range, for ***Renibacterium salmoninarum*** of 2552 kidney samples[2] from Bonneville fall chinook salmon by spawning date in 1993 for Bonneville Hatchery 93 brood year production. The total number of fish and the percent (%) if the 2552 fish sampled within each range are at the bottom of each OD range column.

Spawning Date	Number of fish per ELISA OD_{405} Range						
	.000-.099	.100-.199	.200-.399	.400-.599	.600-.799	.800-.999	>1.000
11-01-93	135	3	2	o	20	o	1
11-04-93	122	2	0	o	0	1	1
11-08-93	179	2	0	o	0	0	1
11-10-93	294	2	1	o	0	0	0
11-15-93	470	4	1	2	0	0	2
11-18-93	321	0	2	0	0	0	0
11-22-93	379	3	1	1	0	0	2
11-24-93	133	5	0	0	0	0	0
12-02-93	443	7	0	5	2	1	2
Total (%)	2476 (97.02)	28 (1.10)	7 (0.27)	8 (0.31)	22 (0.86)	2 (0.08)	9 (0.35)

1 *These analyses were done and data provided by the ODFW Corvdllis Fish Pathology Laboratory funded under a Bonneville Power Administration Bacterial Kidney Disease contract.*

2 *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.*

Appendix Table A-36. Proportions and prevalences (%) of infectious hematopoietic necrosis virus (IHNV) detected in individual ovarian fluid (OF) and milt (M) samples. and five-fish pooled pyloric caecalkidneylspleen (PKS) samples from Carson spring chinook salmon spawned in 1993 at Carson National Fish Hatchery for Umatilla Hatchery 93 brood year production.

Date sampled	Proportion and prevalence (%) of IHNV		
	OF	M	PKS
08-11-93	65/80 (81)	6/43 (14)	12/12 (100)
08-16-93	73/146 (50)	2/74 (3)	ND
08-25-93	19/20 (95)	1/10 (10)	ND
09-01-93	15/21 (71)	3/10 (33)	ND

Appendix Table A-37. Date and number of Carson spring chinook salmon adults sampled for erythrocytic inclusion body syndrome (EIBS) during spawning at Carson National Fish Hatchery in 1993 for Umatilla Hatchery 93 brood year production.

Date sampled	Number of fish sampled
08-09-93	20
08-16-93	19
08-24-93	21
08-30-93	20

Appendix Table A-38. ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of 80 kidney samples[1] from Carson spring chinook salmon adult females spawned at Carson National Fish Hatchery in 1993 for Umatilla Hatchery 93 brood year production.

Date sampled	ELISA OD_{405}	Date sampled	ELISA OD_{405}
08-09-93	.012	08-16-93	.010
	.014		.010
	.014		.011
	.015		.011
	.016		.012
	.016		.012
	.017		.014
	.017		.015
	.019		.015
	.022		.016
	.024		.016
	.024		,017
	.025		,017
	.025		,017
	.026		.020
	.030		.021
	.030		,023
	.032		.074
	.035		.289
	.173	08-30-93	.007
08-24-93	.008		.008
	.009		.008
	.011		.009
	.014		.010
	.016		.010
	.017		.012
	.017		,013
	.017		.013
	.017		.014
	.021		.014
	.021		.015
	.022		.015
	.022		.015
	.022		.016
	.023		.016
	.024		.018
	.025		.019
	,032		.021
	.036		.029
	.036		
	.039		

[1] *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.*